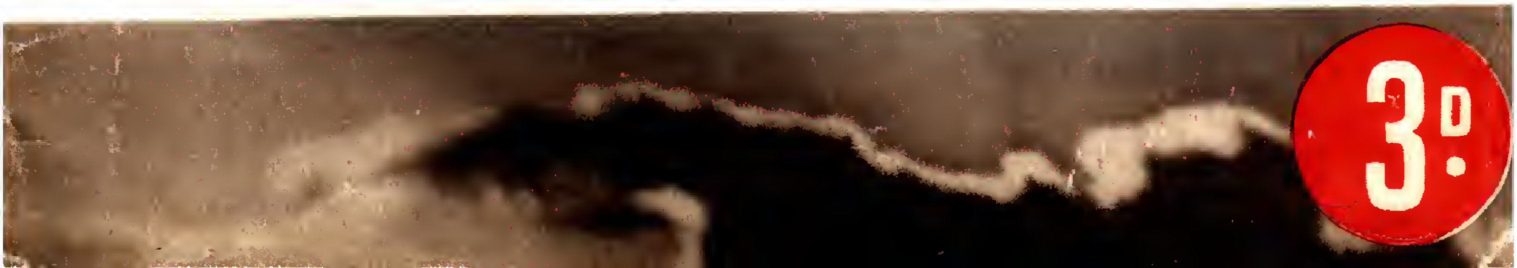
MINISTRY OF HOME SECURITY

1940

WHAT YOU MUST KNOW

WHAT YOU MUST DO



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MINISTRY OF HOME SECURITY

AIR RAIDS

What You must know
What You must do

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FOREWORD

BY

SIR JOHN ANDERSON, G.C.B., G.C.S.I., G.C.I.E., M.P.

Minister of Home Security.

This book is written to help you and your family and your friends.

There has been built up in the last few years a vast organisation for Civil Defence; and, thanks to the devotion of a great army of volunteers, the services which it comprises have been welded into a highly efficient force. This organisation is briefly described in the first chapter, which has been included in this book for two reasons; first, because I may, in the near future, have to call on many of you to give some part of your time to one or other of these services, and secondly, because you may need the help of the services and should therefore understand something about them.

But the Civil Defence services alone cannot protect you from the consequences of air raids. Your own protection and the protection of your family must, in large measure, depend on your taking certain necessary precautions. You can yourself do much to minimise risk to yourself and to those dependent on you.

A great deal of information has been collected as a result of experience gained in actual air raids, and from this and from research and experiment the basic principles on which the protection of life and limb and property depends have been worked out and are set down here for your guidance. They are simple to understand and easy to carry out; and if you will act on them you will be able to face the dangers of air raids with the sure conviction that you have done all in your power for the safety of those depending on you, and with the calmness and assurance that come from a knowledge of the way in which these dangers can be met. In this way you will be helping not only yourself, but the Nation, for it is through the strengthening of your powers of resistance that the people of this country will be enabled to defeat every attempt the enemy may make to weaken its morale and paralyse its war effort.

In this war every man and woman is in the front line. A soldier at the front who neglects the proper protection of his trench does more than endanger his own life; he weakens a portion of his country's defences and betrays the trust which has been placed in him. You, too, will have betrayed your trust if you neglect to take the steps which it is your responsibility to take for the protection of yourself and your family.

This is a contribution to the winning of final victory which you personally can make and which no one else can make for you. I am confident that you will make it.

John Anderson

Ministry of Home Security.

June, 1940.

CHAPTER 1

THE CIVIL DEFENCE SERVICES.

Introductory.

The object of enemy air raids is to dislocate the war effort of the nation. The attainment of this object may be sought by deliberate attacks on targets of military significance, a term having a wide application in these days, or by unrestricted and indiscriminate bombing of the civil population. The primary responsibility for resisting the enemy's efforts lies with the active defence services. But it is essential to have available a nation-wide organisation, the purpose of which is to minimise the effects of air raids by such aircraft as succeed in penetrating the active defences. Such an organisation, known as Civil Defence, has been built up and forms what might now be referred to as the Fourth Defence Service. The operation of this service is the responsibility of local authorities in the United Kingdom, working under the general direction of the Ministry of Home Security.

The tactics of bombing from the air vary from mass raids by large numbers of bombers to attacks by small numbers of aircraft or even by single machines. Attacks may be launched in single raids with long intervals between each raid, or in successive raids following closely upon each other both by day and by night, and maintained over an extended period.

Whatever form aerial attack takes, damage of some kind is inevitable, and the lives of many civilians will be endangered, unless certain essential elementary knowledge is previously gained, and a number of simple precautions observed.

The most effective weapon for causing major damage from the air is probably the high explosive bomb. Its destructive effects are immediate, and it is a difficult weapon against which to provide complete protection except at a very high cost. To cause numerous major fires simultaneously over a wide area may also be an enemy objective, and this may be done by means of incendiary bombs, particularly those of the lighter type, thousands of which could be dropped at one time upon a densely built-up area. Machine-gun fire also may be directed from low-flying aircraft upon persons exposed to the raiders. The possibility of poison gas being used, though it is forbidden by the Geneva Gas Protocol of 1925, cannot be overlooked, and such attacks might be made either by bomb or spray or both.

All these weapons of air attack may be used by themselves or in effective combinations devised to cause the greatest dislocation of the war effort of the nation, and to threaten the morale of the people.

The Organisation of Civil Defence.

There is much that citizens can do, and which no one can do for them, to help themselves, their families, and the nation, but it has been necessary to set up in addition the great organisation of Civil Defence, built principally on unpaid voluntary service, for the discharge of the many skilled duties described below. Everyone should understand this organisation, both so that he may

be able to help so far as he is able, and so that he may not fail to take advantage, in case of need, of the services which have been set up.

The Warning System.

A means by which warning of an approaching raid can be given to the general public is of first importance, and this is provided by a national system. Warning messages are sent out to the districts where air attack may materialise, and in those districts only is the "Action Warning" sounded by sirens. The signal is a "warbling" note given on a variable-pitch siren, or a succession of 5-second blasts sounded on a fixed-pitch hooter followed by intervals of 3 seconds. The warning is then taken up locally by sharp blasts on police and wardens' whistles.

When the raid has passed or is no longer expected, this is announced by a continuous blast, known as the "Raiders Passed" signal. All siren signals are sounded for a period of two minutes.

If the presence of gas is suspected, warning of it is given locally by wardens' hand-rattles; and when the area is known to be safe again, this warning is cancelled by the ringing of wardens' handbells. Handbells may also be sounded to inform the public when it is again safe to emerge from shelter, if sirens are put out of action as the result of a raid.

Air-Raid Wardens.

There will be a great need in time of air raids for persons of courage and personality, with a sound knowledge of the locality, to advise and help their neighbours, and generally to serve as a link between the public and the authorities. To provide for this, the Air Raid Wardens' Service has been organised, based on a large number of local Posts.

Wardens have important duties to carry out, including assessing air-raid damage, reporting it concisely and correctly, guiding and assisting the A.R.P. services sent to deal with it, and giving general assistance and guidance to members of the public. Their functions are in some respects allied to those of the police, with whom they will need to co-operate closely; and, though they are not part of the police or special constabulary, the wardens' service is generally placed by the local authority under the executive control of the Chief Constable.

It is important that everyone should know the names and addresses of the nearest Wardens and the position of the Warden's reporting post, since it may be necessary as a result of air-raid damage to make immediate contact with a Warden, or to arrange for the making of an urgent report.

Auxiliary Fire Service.

It is important that fires should be tackled as soon as they are started, as they are very much more easily put out at this stage than later. Incendiary bombs may cause fires in such large numbers in a comparatively restricted area that the normal resources of the Fire Brigade will be inadequate. An Auxiliary Fire Service has therefore been formed and trained to reinforce the regular fire brigades. The fire brigade equipment has also been increased by the provision, on loan to the local authorities, of large numbers of pumping units, mainly trailer pumps, drawn by cars, taxis, vans or lorries, but including also self-propelled units where required. Emergency fire floats have also been added to the fire brigade equipment in a number of areas.

First-Aid Parties.

There may be injured who must be given attention where they lie; some will require removal for further treatment. For this work there are First Aid

(or Stretcher) Parties, each consisting of four men with a driver and transport for themselves and vehicles for the injured provided by the Ambulance Service.

First-Aid Posts and Hospitals.

There must be places where the lightly and seriously injured can be treated, and this is done at First-Aid Posts and Hospitals. First-Aid Posts are normally in buildings adapted and equipped for this work. They are supplemented by Mobile Units, consisting of vehicles in which the appropriate equipment and staff are conveyed to scenes of damage in order that temporary First-Aid Posts may be established nearby.

In rural districts First-Aid Points are established, and consist of a first-aid box placed in some central building where attention to the injured can be given.

The position of First-Aid Posts and Points should be known to all who live in the vicinity, for it may be necessary for slightly wounded persons to go there on foot, or for uninjured persons to convey a neighbour, for the purpose of obtaining first aid.

Rescue Parties.

Those who have been trapped in shelters or under buildings must be released. This work requires experience and care, since debris unskilfully moved might release other parts of the structure, and so cause it to crash upon both rescuers and those to be rescued.

This work is done by Rescue Parties, who will also undertake the temporary shoring up or the demolition of partly collapsed buildings where these are a source of immediate danger and the work is within their scope. As it is probable that many of the trapped will be injured, at least four members of each Rescue Party are also trained and equipped to render first aid.

For certain parts of rescue party work, for example, the removal by manhandling of piled-up debris, Rescue Parties may ask for the assistance of able-bodied members of the public who are available nearby.

Demolition and Repair Parties.

After an air raid extensive demolition work may have to be done, streets cleared of wreckage, craters filled in, and fractured gas, water, and electricity mains and sewers may need repair. Such work may have to be carried out urgently in order to remove danger, or for the purpose of restoring essential services. Work of this kind will be undertaken by parties obtained from local authorities' staffs or the staffs of public utilities as required, or from contractors, according to the particular work to be undertaken.

In clearing wreckage, demolition and repair parties may, like Rescue Parties, utilise the services of members of the public who are willing to help.

Gas Identification Service.

If poison gas is used, wardens will immediately report the fact. They will also warn the public. There may arise problems in connection with gas warfare, however, which require the services of experts, and to provide for this a local Gas Identification Service, consisting of specially trained chemists and assistants, has been formed and equipped with apparatus suitable for their specialised duties.

Decontamination Squads.

Areas where persistent gas has fallen are said to be contaminated, and are dangerous until the gas has been neutralised or removed. The work of

decontamination is related generally to that of the Street Cleansing Services, and special Decontamination Squads, consisting of a foreman and five men with the addition of a driver, have been recruited, principally from these services, for the work.

Treatment of Unexploded Bombs and Wrecked Aircraft.

Bombs from enemy aircraft or shells from our own anti-aircraft guns may fall without exploding; these are a potential source of danger, and their presence and exact position should be immediately reported to a Warden or the Police. They will then be removed or destroyed by parties specially trained in this work, and in the meantime they should not be touched.

Similarly, a crashed enemy aircraft is also dangerous. If it catches fire, the petrol, ammunition, and any bombs still remaining in their racks may explode. If the aircraft is not on fire, there still remains a possible danger of explosion.

It will be the duty of Wardens and the Police to keep the public away from unexploded bombs, shells, and crashed enemy aircraft, and to arrange, as necessary, that nearby buildings are vacated until the area has been made safe by the appropriate means.

Report and Control Centres.

For the operation and control of all A.R.P. services, there must be local headquarters to receive damage reports and to issue instructions for the despatch of the necessary parties to scenes of damage. For this purpose Report and Control Centres have been established. These are manned by telephonists, messengers, clerks, and representatives of the various A.R.P. services, who are co-ordinated by an Officer-in-Charge.

A Report and Control Centre may be combined, or there may be one or more Report Centres linked to the Control Centre, which is the nerve-centre of the local organisation and the headquarters from which local operations are directed.

A.R.P. Controllers.

The local A.R.P. services are under the general charge of an A.R.P. Controller, whose duty it is to maintain the smooth and efficient working of the various A.R.P. services of the local organisation and who is supremely responsible for their operations in times of raiding.

CHAPTER 2

SELF-PROTECTION AGAINST HIGH EXPLOSIVE BOMBS, AND BEHAVIOUR DURING A RAID.

High Explosive Bombs and Their Effects

A high explosive bomb consists of a charge of high explosive mixture contained in a steel case fitted with a fuse and exploder.

The destructive effects are twofold : those of blast, i.e. the air pressure and waves created by the explosion, and those of fragmentation, i.e. the breaking up of the steel case of the bomb into jagged pieces or splinters.

Splinters.

The average size of these splinters is about 1 in. across, and they are projected in large numbers in every direction at about twice the speed of a rifle bullet. On striking a hard surface they may be arrested or, if deflected in their path, may cause damage from an unexpected direction.

The effective range of splinters can be considerable, and unless sufficient resistance is encountered in their path, they may inflict fatal injury at points as far distant as half a mile from the fall of the bomb.

Blast.

Blast is more freakish in the havoc it brings and a detailed treatment of the subject would involve a technical description of scientific phenomena. It is sufficient to say here that on the bursting of a bomb there is a violent outward movement of air in the immediate vicinity of the explosion, followed instantly by a great inrush of air causing a momentary suction. A shock-wave is created and travels at a velocity, in the first instant, greater than that of sound; but it quickly becomes weaker as it goes. If the explosion takes place after penetration of the ground surface, corresponding waves are also set up in the earth.

In the immediate vicinity of the bomb, shock-waves may completely destroy buildings or may partially destroy them by causing the collapse of wall panels, roofs, doors, and windows. These are the " near effects," caused by pressure or suction.

Further away, only structures of light construction, such as prominent balconies, and roof tiles and slates, plaster from ceilings, and window glass are likely to be affected. These are the " distant effects," caused by violent shaking.

It can never be predicted, especially in the case of doors and windows subjected to the near effects of blast, whether they will be blown violently inwards or sucked outwards. It can, however, be said that the glass of unprotected windows will almost certainly be shattered, and that the flying jagged pieces will be a source of the utmost danger.

Window glass subjected to distant effects of blast may also be shattered, but with considerably less violence, the fracture being caused by the resonance set up in the panes by the shock wave. If windows are left wide open they are less likely to be broken. It is advisable, however, to close them if a gas warning is given, and bombing is not in progress at the time.

Far greater areas are exposed to the distant effects of bombs than to the near effects, and consequently the chance of a house being subjected to distant effects is far greater than that of its suffering nearer effects.

Types of H.E. Bombs.

There are certain types of H.E. bombs, such as anti-personnel and armour-piercing bombs, designed for attack on specific objectives, but the most commonly used are the General Purpose types. The latter, as the name implies, are employed for general bombardment purposes and are used, for example, against factories and buildings of ordinary construction.

These bombs may be fitted with fuses to detonate them on impact or after a delay varying within a considerable time range; normally they have fuses giving a delay action of a few tenths of a second in order that the target may be penetrated before detonation, but the delay can be increased to many minutes or even longer periods.

The weights of bombs vary greatly. In determining the size of bomb to be used, account has to be taken of the carrying capacity of the aircraft, the weight of fuel required, and the destructive effect of the different weights of bombs. In the present circumstances, the bombs most generally in service are of about 100 lb., 250 lb., and 500 lb.; such bombs are between 4 and 5 feet long; and from 9 to 15 ins. in diameter.

High Bombing Attacks.

Hostile aircraft will be subjected to heavy anti-aircraft fire from our home defence units. Over certain vulnerable parts of the country, barrage balloons, too, will add to the hazards with which they must contend, and at all times there will be the Fighter machines of the R.A.F. launching fierce attacks upon the enemy.

These defences will tend to cause raiding units to keep as far out of range as they can, consistent with the requirements of their plan of bombing. In many cases, therefore, the majority of bombing attacks over this country may be expected to be launched from a considerable height.

There are two points arising from this source which are of special interest to the civilian population.

Firstly, even if it could be assumed that the enemy would confine his attention to military targets, the small measure of accuracy obtainable when bombs are released from a great height leaves a wide margin as regards the possible positions where the bombs might actually fall. Some may fall in the areas at which they are aimed, whilst others would almost certainly fall in residential areas, the suburbs of cities, or even in parks, fields, or rivers. Every citizen, then, must realise that he and his family are among the potential victims of air attack, and that he must take all possible steps to secure protection.

Secondly, bombs released from modern aircraft flying at great heights and speeds must be released well before the target is reached. Anyone who waits till he sees aeroplanes overhead before taking cover is thus running the gravest risk of being injured by the bursting of a bomb dropped before the bomber comes into sight—for in congested areas in particular it is most unlikely that there will be clear view of the sky for many miles in all directions.

Low Flying Attacks and Machine Gunning.

Where there is no balloon barrage, attacks may be made from very low altitudes, or by dive-bombing, and aircraft may skim over the roof-tops spraying unprotected persons in the streets and at windows with machine-gun bullets.

Other Falling Projectiles.

In addition to the dangers resulting from H.E. and machine gun attacks, and from incendiary bomb and gas attacks described in later chapters, there are other falling missiles inseparable from the presence of hostile aircraft over this country. Anti-aircraft shells are designed to explode in the air, and the fragments of metal, including the heavy nose-cap, will descend upon the country below. Expended machine gun bullets resulting from aerial combat will also fall to the ground.

The Importance of Shelter.

These, then, are some of the dangers which air raids will bring. Outside the very small area in which the severest consequences of a direct hit are felt, there is a large area in the case of each bomb explosion in which there are the gravest dangers to life for the unprotected, as has been explained in the foregoing pages, but against which it is perfectly practicable to provide protection simply and cheaply. Every time a bomb explodes in a congested area, for a large number of people in the vicinity it may make the difference between life and death whether or not they have provided themselves with shelter and, on hearing the sirens, have taken refuge in it.

A vital responsibility therefore lies on each householder to ensure that adequate shelter is available for himself and his dependents. In order to assist persons who wish to avail themselves of expert advice as regards the selection of the form of shelter best suited to their own case, certain of the Professional Institutions have arranged, with the approval of the Government, to set up a panel of Engineers, Architects, and Surveyors who are competent to give technical advice to householders. For the sum of 10s. 6d. a member of the panel will inspect the house and give the householder a brief written report as to the best place for a shelter and the best way within his means to provide protection.

A list of consultants on the panel has been furnished to certain local authorities and on application to the authority a householder may obtain a list of consultants from which to choose. If the authority has no such list, application should be made to The Secretary, Central Board, 1-7 Great George Street, Westminster, London, S.W.1, who will provide the name or names of consultants available near the householder who applies.

Provision of a Refuge in the House.

In many cases it will be found that the most convenient means of providing a shelter is to adapt some part of the existing premises for the purpose, and this is something which very often a handy man can do for himself, using largely materials which he can find in his own house or garden.

Full-scale experiments conducted with 500-lb. bombs have shown that, outside a radius of 50 ft. from the point of burst, the average well-built house of normally substantial construction should give its occupants substantial protection against the effect of blast and splinters, as well as against machine-gun bullets and light missiles, subject to certain provisions being made. Windows and doorways should be blocked up or protected in some other way; ceilings must be supported in case of the collapse of the roof or upper storey; where walls are thinner than 13½ ins. of sound brickwork or stonework or the equivalent of this, they must be reinforced by the addition of further material, such as earth in boxes piled beside the wall to a height of at least 6 ft.

Selection of a Refuge.

The considerations may broadly be divided into two parts; those of lateral protection, that is, protection from blast and splinters provided by

side walls, and those of overhead protection against light incendiary bombs, fragments of anti-aircraft shells, machine gun bullets, etc., and against the fall of debris, should the upper parts of the building collapse.

Basement and semi-basement rooms offer the best natural protection, since lateral protection is generally wholly or partly provided by their sunken position, and they probably have fewer windows to be blocked or protected than other rooms. As regards overhead protection, there are all the floors and the roof of the building above them to give protection from falling objects, though they may not possess adequate strength to take the load of the building should it collapse. It is desirable to obtain professional guidance as to whether the ceiling is capable of taking the weight of falling debris, and, if not, how best it can be strengthened for the purpose.

Where there is no basement, it will usually be advisable to select a room on the ground floor or one of the lower floors, in order to ensure good overhead protection against falling missiles; wherever possible there should be two floors and a roof above the shelter. Rooms on higher floors are inconvenient to adapt, since it may be necessary to protect the floor from splinters striking up through a window of the room below, and the strengthening of the ceiling also is most difficult and often impossible to arrange.

In the case of rooms at or above ground level, it is necessary to consider the thickness of the walls upon which lateral protection will depend. A shelter should, if possible, be protected by 13½ in. of sound brickwork or stonework on all sides. It is not necessary that the walls of the shelter room itself should everywhere be of this thickness, provided there are other walls within a distance of about 30 ft. which give on all sides a total thickness equivalent to 13½ ins. of solid brick or stone; if in any direction this degree of protection is not afforded by the premises as they stand, additional material should if possible be added. If it is not practicable to provide a thickness of 13½ ins. in all directions, a single 9-in. wall of sound brick or stone will give considerable protection.

Other things being equal, rooms facing soft ground, such as gardens and fields, are more suitable for use as shelters than those looking out on a street or hard paving, since the destructive effects of a bomb bursting in soft soil are not so great as those of one in contact with a hard surface.

Persons living in the upper storeys of houses converted into flats will need to come to some arrangement with the other occupants so that common protection can be secured for all in the manner most suitable to all the circumstances. Those living on the ground floor or in the basement might give up space in an entrance hall or passage, whilst others might provide material and labour for blocking up a window or making other structural adaptations, or it might be possible to adapt quite simply a common staircase for use as a refuge by all.

Protection of Windows and Doors.

After a suitable room has been selected as a refuge, the windows and any outside doors will need to be given special protection. Windows in particular are highly vulnerable to both splinters and blast, and even when situated below ground, and thus protected against splinters, they may still be affected by blast. Moreover, they may be broken by the vibrations set up by distant effects in situations where no splinters can reach them.

Protection against Splinters.

One method of protecting windows against splinters is to remove the window frame and fill in the opening with brickwork of the same thickness as the wall. Another method is to build, outside the window, a wall of brickwork

13½ inches thick, or of earth or sand 30 inches thick, or of ballast or broken bricks 24 inches thick; where materials other than brick are used, they may be contained in boxes, or held between boards or corrugated sheet iron. Protection can also be improvised by placing boxes tightly packed with books to a thickness of at least 24 inches against the inside of the window.

Protective walls for windows should extend completely across the opening, overlapping it by one foot on each side and at the top also.

A saving can be made in the materials used to provide protection by erecting them on a strong platform or table placed at least one foot below the window to obviate building up the walling from the ground level.

As far as bomb splinters are concerned, protection need not extend above 6 feet from the floor, as persons in the refuge will then be safe from such splinters, though the window will, of course, be vulnerable to blast.

Similar protection can be given to doorways in outside walls, provided the entrances do not have to be used, except possibly under force if other ways of exit become blocked. Where the door is a regular means of entrance and must be kept free, a substantial traverse should be built to a height of at least 6 feet and to a width greater than that of the doorway, and 3 or 4 feet away from it.

Protection against Blast.

Windows and doors which are fully protected against splinters by the foregoing methods will generally be protected against blast. But there will be

A stout book-case, stuffed tightly with old books, protects one window. Or a table can be used with books 2 ft. 6 in. thick piled on it. If the books are loose they should be roped down firmly.

many windows of a house, notably those of rooms other than the one adapted for use as a shelter, which will cause great inconvenience if shattered. No protection can be obtained simply for these against near effects, but some measure of reinforcement can be given to them against distant effects and the risk of small pieces of glass flying about reduced by one of the following means :—

(1) A piece of fabric such as muslin, calico, cotton, or linen sheeting may be pasted all over the glass. A variety of adhesives can be used, such as office paste, gum, size, paperhanger's paste, or ordinary flour paste with an addition of treacle or glycerine in the proportion of one part of treacle or glycerine to twenty parts of the adhesive. Waterglass (sodium silicate) should not be used. The glass should be well coated with the adhesive. Where the loss of light does not matter, a strong cardboard may be pasted over the glass. In order to make the cardboard stick, its natural curvature should be noted and it should be placed with its hollow side, which may also be coated with the adhesive, facing the glass and then be pressed firmly in contact. When there is not enough cardboard available a strong wrapping paper can be used, but it will not be equally effective.

(2) The inner face of the glass may be sprayed or painted with a liquid composition of which special varieties can be bought. These materials mostly have only a limited life, and may have to be renewed after about two or three months.

(3) A transparent film of the kind used for wrapping may be applied to the inner face of the glass. It can be pasted over the whole window, or it can be applied in strips at right-angles. There are several materials of this kind and each requires the proper adhesive. The makers' directions should be followed closely.

(4) Where none of the above recommendations can be followed, materials can be applied in strips, though they do not prevent glass from splintering quite so well as all-over coverings. Surgical plaster or insulating tape are useful and are best pressed on with a warm iron. Strips of wrapping paper are not so satisfactory because they tear more easily. The strips should not be more than 6 inches apart.

In all cases in which glass is retained in the windows of refuge rooms, unless the opening has been wholly blocked, it is essential to arrange protection against the violent scattering of broken glass by one or other of the foregoing methods.

Keeping out wind and rain when windows are broken.

If window panes are shattered, it will be necessary to keep out wind and rain and possibly poison-laden air. For this purpose, a shutter made of wall-boarding, plywood, or other stout material fixed to a light wooden frame, accurately fitting the window opening and having felt or thick cloth tacked around the edges, is recommended. This wall-board shutter should not be secured in position except by the friction of its close fit assisted by the felt around its edges; it will thus not offer resistance to blast, and, if blown away from the window, will fall into the room undamaged and can be easily replaced. It will be found useful to attach the top edge of the shutter to the wall by two lengths of stout rubber about 18 inches long, so that, while it is left free to swing from the window, it will be prevented from flying across the room.

Alternatively, shutters made of wood 2 inches thick throughout may be fixed on the outside of the window. These wooden shutters must be firmly clamped to the wall, for instance, by iron bars fixed across them with the ends securely fastened to the wall. While such shutters will not prevent the glass from being broken by blast, they will themselves normally withstand the effects of blast, and, if fitted with the necessary gaskets, will also keep out poison-laden air.

Provision of a Shelter Outside the House.

In some cases it may be decided to provide a shelter of special construction outside the house. Such a shelter may take one of several forms and may be situated in the garden, if there is one, or nearby, wherever accommodation permits.

Arrangements may be made with neighbours for two or more householders to share the expenditure of a commercially built structure situated conveniently to all.

The entrance of such shelter must always be protected from splinters either by means of a substantial traverse or by proximity to a substantial building or wall. The shelter should be sited not nearer to any building than half the height of that building. Where this cannot be achieved, the roof of the shelter must be made strong enough to resist the fall of debris.

Generally it is found that the proper siting and erection of outside shelters are matters for the building and contracting profession. For that reason, only brief notes are given in the pages which follow on the various types of outside shelters, sufficient to indicate the kind of problems to be tackled. Those wishing to provide for themselves specially made shelters are recommended to make contact direct with the profession or to approach the local Council for guidance, whichever is more appropriate.

Types of Shelters independent of Buildings.

Shelters independent of buildings may take the form of covered trenches or they may be special constructions, lined for example with steel or concrete.

Trenches.

Being constructed wholly or partly below ground, trenches afford excellent lateral protection, but they must be given overhead cover against light falling missiles. This requires a head cover of 5 inches of concrete or 18 to 24 inches of earth. More earth should not be used, because, in the event of collapse, the occupants of the shelter might be so deeply buried as to be unable to extricate themselves.

Trenches should provide not less than 6 feet of head room and should be fitted with seats. They must be lined with strong materials to prevent the walls from collapsing, and should be provided with a form of floor covering, such as duckboards or shingle.

Arrangements must be made to drain away any water which may seep into the trench.

Government Steel Shelters (" *Anderson Shelters* ").

Corrugated steel shelters made in sections to accommodate four or more persons made to Government specification have been distributed in large numbers in the more vulnerable areas.

The sections of these shelters fit together in the form of an arch designed to carry the necessary covering of earth for overhead protection against falling

A Completed Anderson Shelter.

splinters and debris. Where possible, they should be sunk about 3 feet into the ground, and should invariably be covered with earth to a minimum depth of 15 ins. over the arch. These shelters do not provide the required protection unless covered by at least this thickness of earth. The shelter should be sited from 6 to 15 feet away from a building in such a position that the building protects the entrance from splinters.

Surface Shelters.

These are built entirely above the ground; they may be constructed of 15 inches of concrete, 12 inches of reinforced concrete, or 13½ inches of brickwork. Overhead cover must be provided against the fall of light missiles, and for this purpose reinforced concrete 5 inches thick may be used.

General Notes on Shelters.

Before a refuge or shelter can be considered to be completed and equipped, there are certain points to which attention must be directed. It is important

that these matters be attended to immediately the accommodation is available and not left until just before or during an air raid, when it may be too late.

Entrance and Exit.

Where possible two entrances, or a main entrance and an emergency exit, such as a window, should exist; they should be as far apart as possible, so that both are not likely to be blocked at the same time.

Independent Lighting.

As the normal source of electricity may be damaged, it is important to provide alternative means of lighting. In small shelters torches, or even candles and night-lights, may be used for alternative lighting.

Water Supply.

An adequate supply of drinking water should be available.

Flooding.

Steps should be taken where necessary to prevent the entry of rain water or water from mains damaged in a raid.

This may be done, for example, by provision of tide boards or by the heightening of parapets round the site of the shelter. Underground shelter accommodation should not be discarded solely on account of the fear of flooding, if means can be provided for the safe escape of its occupants.

An enlarged coal shute protected from debris can be arranged as an emergency exit from cellars.

Sanitary Arrangements.

For this purpose, chemical closets may be used if water closets are not available. Some provision, however, is essential.

Tools.

A number of tools such as picks, shovels, and crowbars should be kept in a shelter to be used in forcing a way out if the occupants are trapped. When the accommodation is being fitted out, it should be discovered where the weakest part of the structure is, or where it would be most suitable to work, should it become necessary to break a way out. This position should be clearly marked for the benefit of all.

Comforts and Occupation.

Chairs or other seating arrangements are required, and a table, if it can be accommodated, is desirable. Rugs and a stove will be found most welcome during night raids and in the winter months. A radio or gramophone, some books, table games, and toys where children are concerned, will also be found useful adjuncts to shelter equipment. The provision of a kettle, a safe means of boiling it, some tea or coffee, a few biscuits in tins and perhaps some tinned food in addition, will all help to make less irksome the time passed in the shelter.

It is important that persons in shelters should be given an occupation, preferably of the mind, since this will help to divert attention from the noise accompanying an air raid and to prevent idle speculations on what is going on outside. Vigorous activity in a shelter should be discouraged, since it increases the consumption of oxygen out of the air and unnecessarily raises the humidity.

If a dog is taken into the shelter, it is desirable that it should be muzzled.

Action to be taken on the Sounding of a Warning and Behaviour during an Air Raid.

It cannot be too strongly emphasised that it is most dangerous to give way to the temptation to watch what is going on in an air raid, and to remain out of doors or at a window instead of taking cover. Even if the raid is a considerable distance away, fragments of anti-aircraft shells may fall many miles from the scene of action, and in addition, with aircraft travelling at several miles a minute, a person watching a raid at some distance may find himself without warning in the middle of falling bombs. Owing to the great speed of modern aircraft, the bombs are released many miles before the target aimed at is reached, and the person who waits to see the bombers before taking cover may pay for his curiosity with his life.

When an air raid warning is heard, or the sound of gunfire or falling bombs is heard in the absence of any warning being sounded, it is of the utmost importance that everyone should seek cover at once, taking care that he has his respirator with him.

After a warning is sounded, the period before the raid begins is likely to be short. Persons in or near their own homes should betake themselves, with their dependents, in an orderly fashion, to the refuge; and employees at their place of business should take cover in the shelter provided. Those caught in the streets at the time of an air-raid warning should not attempt to go home, unless they can get there within five minutes. The local authorities, assisted by the Government, have provided public shelters for use by those persons for whom it would be unsafe to try to reach home. The presence of these shelters is clearly marked, and in congested areas they are situated at close intervals.

It is obvious that no time should be lost in finding the nearest shelter. This may not be difficult in daylight, but in the dark—perhaps on a moonless night—it might prove an almost hopeless task if no thought had been given to it beforehand. Signs are provided indicating the location of public shelters, and it should be made a matter of habit to look out, wherever one may be, for these notices, so that in case of sudden need arising to seek shelter no time may be lost in trying to find it.

Where persons are indoors on the announcement of an air raid, even where no refuge is provided, they should remain on the premises and should not make their way to a public shelter. Public shelters are provided for the safety of those who find themselves in the streets and far from home at the time of a raid. It is much safer to remain in an unprotected house than to be caught in the street when bombs are falling.

If a person in the street has not been able to find a public shelter before the raid begins, it is necessary to make the best use of any nearby buildings or other local features which can be turned to advantage as a means of providing cover. Partial protection from flying splinters and debris may be obtainable in archways, doorways, basement yards, under balconies, and against walls. Bodily contact with solid matter, such as with the wall of a basement area, a shelter, or a house, should be avoided since there is a danger of being hurt through the violent percussion or earth shock set up in the ground by the force of a bomb exploding nearby.

Protection of the lungs against blast can be secured to some extent by keeping the mouth slightly open, and this can best be done by gripping firmly between the teeth a piece of india rubber, a piece of soft wood, or a handkerchief rolled up tightly into a ball.

To protect the eardrums from shock it is useful to put a small pad of loosely packed cotton wool in the ears.

In the case of a bomb which penetrates the ground before exploding, the sides of the crater tend to confine the path of splinters to an upward direction, and even in the case of bombs which explode without penetration there is a zone of comparative safety near the ground. It is therefore safer to sit down than to stand up, and safer to lie than to sit. Thus, if a person finds himself in the open in an air raid and no shelter is available, he should lie flat, preferably in a ditch or in a fold of the ground, with face downwards, supporting his head in his folded arms. Protection should be given in any possible way to vital parts of the body against the fall of light objects.

The chart on page 22 gives an idea of the great reduction in the risk of injury which can be secured by acting on the simple precautions described.

After the Raid.

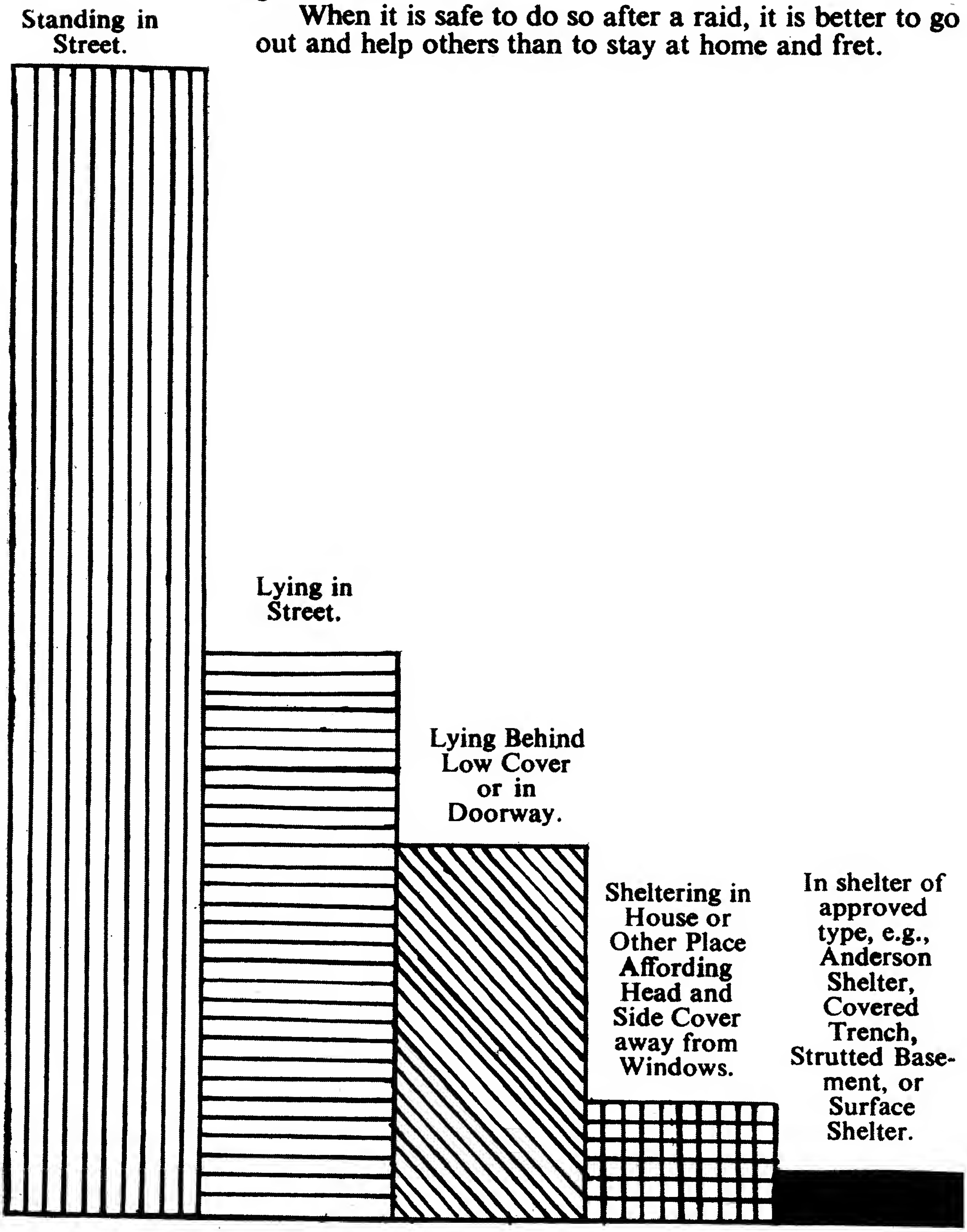
After the action warning has been sounded it is important not to emerge from the shelter until the " Raiders Passed " signal is given. It is even more important that an exit should not be made where gas has previously been announced by Warden's rattle until, in addition to the " Raiders Passed " message sounded by the siren, the " All Clear " is rung on Warden's handbells.

On emerging from shelter, it may often be the first impulse to wish to make inquiries by telephone as to how others in the vicinity have fared. This must not be done, since the communication system of the locality will certainly be required by the Civil Defence Authorities for the purpose of transmitting and receiving reports and for ordering out assistance to the scenes of damage, where the factor of time is of paramount importance. Those whose welfare is causing the most concern may unhappily be involved

at a scene of damage, and the delay in getting help to them caused by unnecessary blockage of the lines of communication may be a deciding factor in their ultimate safety.

During a raid and, indeed, at all times in an emergency, it is necessary to keep calm, and to act swiftly, with the knowledge of the right course which must be gained beforehand.

When it is safe to do so after a raid, it is better to go out and help others than to stay at home and fret.



This diagram is based on a large number of reports of the results of recent air raids and is an approximate indication of the difference in the degree of risk resulting from taking cover in various ways.

CHAPTER 3.

INCENDIARY BOMBS.

Incendiary Bombs and Their Characteristics.

Incendiary Agents.

Many incendiary agents, such as petrol, thermite, phosphorus, and magnesium, have been used in war, but the most effective as a projectile is the Magnesium Bomb, which consists of a magnesium alloy exterior and a core of thermite priming composition.

The chief advantages of this type of bomb are that the whole of it is combustible with the exception of the striker mechanism and the sheet-iron tail fin, and that it remains active longer than most other forms of incendiary bomb of equal weight.

Incendiary Bomb Attack.

Generally speaking, the object of incendiary bomb attack from the air is to cause many fires over a large area at once. To do this each aircraft must carry as large a number as possible of the lightest bombs which will effectively start a fire; for this purpose the " kilo " or 2¼-lb. magnesium bomb offers great advantages since a large bomber can carry 1,000 or more of these bombs.

They may be released in salvos of 10 or 20, and if 15 per cent. of the bombs dropped in a normally built-up area actually hit buildings, a reasonable proportion for such an area, and only half of these started fires, at least 75 fires could be caused by a single aircraft.

If there were 10 aircraft 750 fires might thus be started simultaneously.

Penetration and Protection.

The light incendiary bomb has been designed to penetrate any ordinary roof material, such as slate or tile, and to become lodged in upper storeys, where a fire may result. Unless the bomb enters through a window, it will probably be arrested by the first boarded floor below the roof, where it will start a fire and then, burning its way through the floor, start a further fire on the floor below.

To lessen this risk, it is important to remove inflammable materials in attic or roof spaces. In addition, to prolong the resistance of woodwork to burning, it is helpful to apply liberally on upper roof timbers in these spaces one of the many recognised flame-resisting paints or plasters in accordance with the directions of the manufacturer. It is not difficult, however, and it is certainly far cheaper, to buy the ingredients of such a composition and prepare the mixture at home. For those who may wish to do so, the formula is :—

> 1½ lb. of Kaolin (china clay) to 1 lb. 2 oz. of sodium silicate in syrup form, mixed in 1 pint of water.

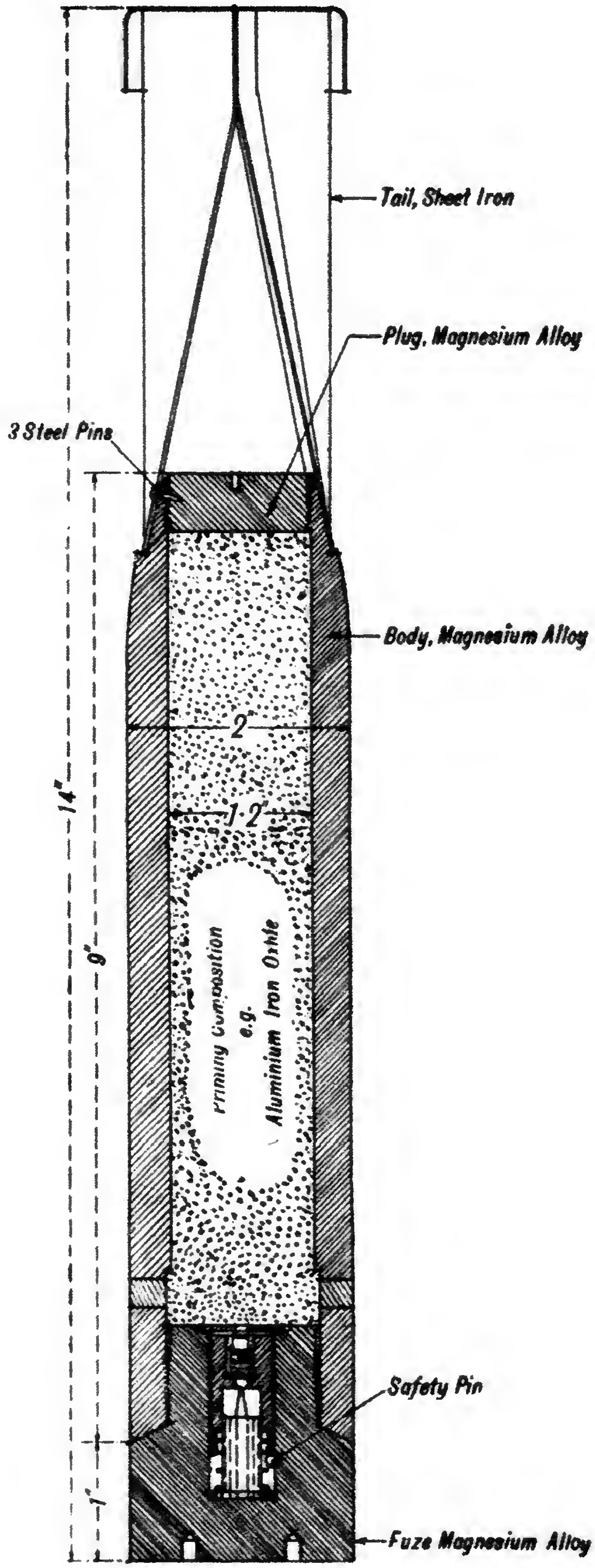
It should be understood that the application of flame-resisting paints and plasters do not prevent fire, but simply prolong the resistance of dry woodwork to burning, thus giving the fire-fighter more time to get to the bomb before

the surroundings are set alight. The resistance to burning in a floored roof space or attic can be greatly increased by covering the floor with 2 ins. of dry sand (if the ceiling structure will support the weight) or with some other suitable material.

Characteristics of Light Magnesium Bomb.

On impact the thermite core of the bomb is ignited and burns at a temperature sufficient to ignite the magnesium casing. In the initial period,

Typical Kilo Magnesium
Incendiary
Bomb.



Typical Kilo Magnesium
Incendiary
Bomb—Sectional Drawing.

normally lasting about one minute, a violent spluttering takes place and molten incendiary matter is thrown a considerable distance, often about 30 ft. This may cause any inflammable material within reach to catch fire. After the initial stage the bomb will have become a small pool of molten magnesium, which will continue to burn with intense heat, but without spluttering, for about 10 minutes or more.

If left alone the magnesium will tend to trickle through floor boarding, burning its way as it goes, and so start further fires in the room below.

When, therefore, an incendiary bomb has penetrated a building, it becomes immediately necessary :—

(i) To subdue and localise the fire resulting from the bomb, since the main damage is caused by the fire;

(ii) To control the bomb and prevent it from burning through the floor.

Methods of Controlling the Bomb and Dealing with Incipient Fires.

The Use of Water.

The effect of applying water to burning magnesium is to increase the rate of burning by supplying oxygen, with the result that the bomb is rapidly burnt out.

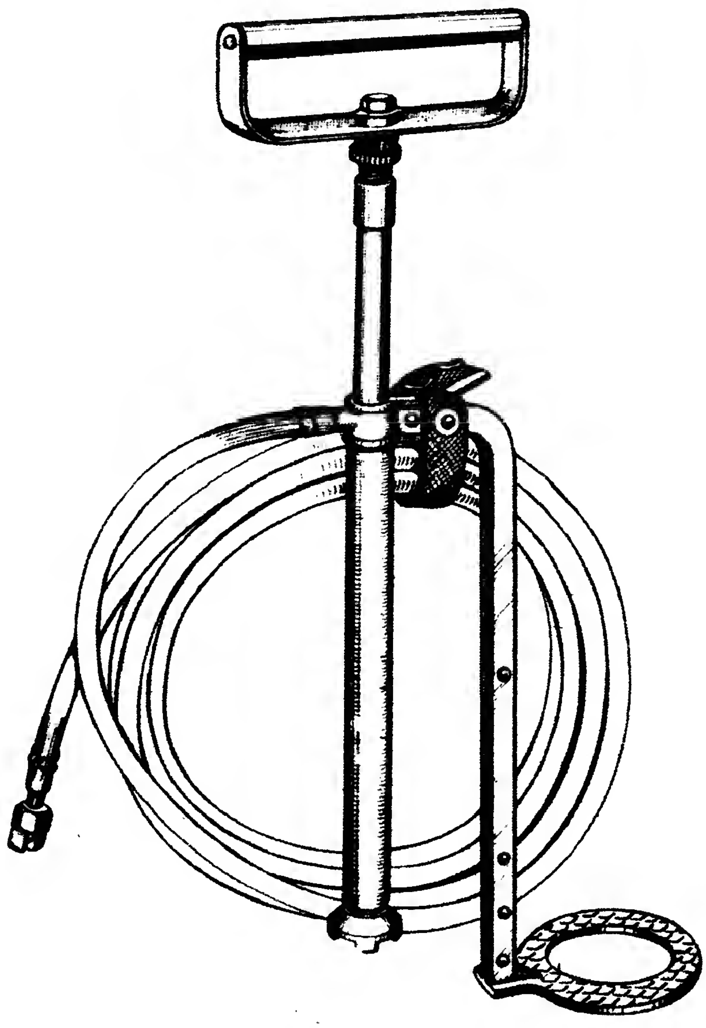
Water should not, however, be thrown from a bucket or otherwise projected in quantity on a magnesium bomb, since this will cause very violent spluttering and scattering of the molten metal. Even a light jet of water will cause spluttering, and should not, therefore, be used on the bomb.

The best method of dealing with a magnesium bomb is by the application of water in a suitable spray, such as that produced by the stirrup hand pump; this enables the bomb to be dealt with at close quarters without any spluttering, and reduces the time of burning from about 10 minutes to a minute or so.

Stirrup Hand Pump.

The appliance specially recommended for dealing with incendiary bombs and the resultant fires is the stirrup hand pump. It is fitted with a dual-purpose nozzle which can produce either a spray or an $\frac{1}{8}$-in. jet of water as desired. The jet will normally carry effectively to a range of about 30 ft., and the spray to about 15 ft. It is supplied with 30 ft. of hose.

The advantages of the stirrup hand pump may be summarised as follows :



Stirrup Hand Pump.

(i) It provides within a single appliance a safe means of attacking both the fire and the bomb; the former with the spray, the latter with the jet. To change from a jet to spray it is necessary only to press a button in the base of the nozzle.

(ii) It enables the person operating the pump to keep well away from the intense heat and smoke.

(iii) It is economical in water consumption. Not more than 6 to 8 gallons of water are required to extinguish the bomb and any resultant fire in the room, provided the situation is tackled promptly.

(iv) It is a valuable means of fighting incipient domestic fires not necessarily resulting from incendiary bombs, and it may also be found to have other uses, for instance in the garden or garage.

Methods of Use.

The appliance may be operated effectively by two people, but three are preferable and they can best work as a team as follows :—

No. 1 takes charge of the fire-fighting and operates the nozzle at the end of the line of hose;

No. 2 pumps the water from a bucket at the other end of the hose;

No. 3 keeps the bucket replenished with water and relieves Nos. 1 and 2 as necessary.

No. 3 should also watch for the possible outbreak of fire in the floor below and in other likely places.

When the team consists of only two persons, the duties of No. 2 and No. 3 should be combined.

An independent source of water supply should be arranged in case water mains are damaged or the pressure of water in them is reduced owing to fire brigade activities elsewhere.

For this purpose, water should be stored beforehand in tanks or buckets, or used bath water may be retained in the bath during periods of heavy raiding.

To approach the fire without being overcome by smoke, fumes, and heat, No. 1 of the team should lie down and keep his face near the floor, where it will be found easier to breathe and to see. He should have a fireman's axe or light domestic hatchet conveniently available for dealing with obstacles in his approach to the bomb, and also an electric torch for use in the final search for smouldering remains. A wet blanket folded and slung across the left arm will help to provide protection against the heat and against spluttering magnesium.

Sequence of Action.

After the initial period of intense spluttering, the situation should be tackled as follows :—

(i) The fire caused by the bomb should normally be controlled first by means of the jet. Until this has been done the operator may not be able to approach the bomb sufficiently closely to direct the spray upon it.

(ii) The spray should then be directed on the bomb, and during this period the operator should gradually work nearer to the bomb so that he is finally attacking it from 6 ft. He should continue to direct the spray upon the bomb until it is entirely consumed, but it may be necessary to stop spraying the bomb occasionally so as to keep the resultant fire under control with the jet.

Controlling Fire with Jet.

Directing Spray on the Bomb.

Shovelling Sand on the Bomb.

(iii) As soon as the bomb is extinct, the operator should extinguish any burning parts which remain in the surrounding space.

(iv) As there is danger of fire creeping into unseen places where it may remain unnoticed in a smouldering condition, a thorough search must be made; for this purpose it may be necessary to lift floor boards or to remove panelling and skirting from the walls.

Alternative Methods.

Where an incendiary bomb is found burning upon an incombustible surface, such as the tiled or concrete floor of a kitchen or scullery, an

The Bomb Almost Completely Controlled by Sand.

alternative technique may be used if the surrounding area has not already been set alight. The principle of this technique is to control the combustion by smothering the bomb with dry sand. A close approach can then be made and the bomb may safely be scooped into a receptacle containing a few inches of sand and so removed outside.

The best appliances for use with this method are the Redhill container and long-handled scoop and hoe. The container should be kept full with dry sand and situated together with the scoop and hoe conveniently near the place where it may have to be used.

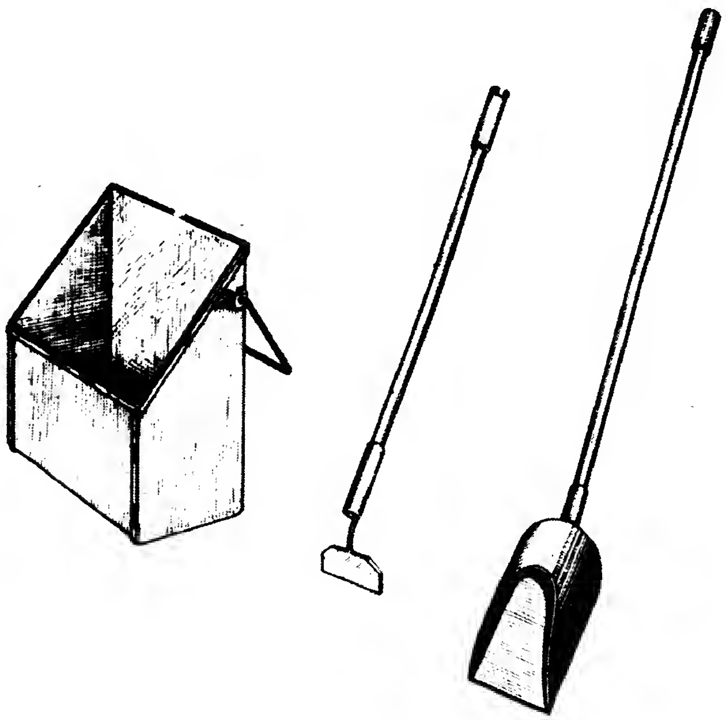
If no other appliances are available, a bucket or coal-scuttle, and a shovel or garden spade, may serve the purpose, provided that a supply of sand, earth, or domestic ash is readily accessible, with which to smother the bomb and to provide a protective layer of a few inches thickness in the base of the improvised container. When the bomb is completely smothered, it may be scooped into the container and removed, care being taken to scoop up every particle of burning molten metal.

Use of Chemical Extinguishers.

Many chemical extinguishers are excellent for the purpose for which they have been designed, but would have certain disadvantages in meeting the situation caused by an incendiary bomb.

The average soda-acid extinguisher is of the 2-gallon type. A single extinguisher of this type would not, as a general rule, be capable of dealing with the bomb and the resultant fire. In addition, it would be difficult to handle when thick smoke made it necessary for the fire-fighter to keep close to the ground.

Some extinguishers designed for special purposes would actually be dangerous; for example, carbon tetrachloride, which is used in some, generates phosgene, a poisonous gas, when in contact with the burning magnesium.



The Redhill Container. The Long-handled Scoop and Hoe.

These are joined together for shovelling sand on the bomb, as shown in the illustration on page 28.

Larger Fires.

If an incendiary bomb is not dealt with quickly, a serious fire may result and the situation will probably call for the resources of the organised fire service. In order to prevent the spread of fires, it is essential that the fire service, if required, should be called without delay. It is of vital importance, therefore, that everyone should know the fire organisation in his locality and the quickest way of obtaining assistance. Telephone lines and fire alarms may well be congested or out of order, and it would be wise to have a notice pinned up near the door stating where the nearest fire station or auxiliary fire station is or the route followed by the fire patrols.

In addition, the following notes may be found useful by householders for dealing with a situation where a serious fire has been started.

(*a*) In searching a house for occupants, a start should be made at the top and continued downwards.

(*b*) To avoid smoke and heat, a person should lie down and crawl with head low. This method applies equally to life-saving and fire-fighting.

(*c*) Doors and windows must be kept closed to restrict the supply of fresh

air to the fire. The door of a room in which there is believed to be a fire should not be opened until appliances are ready and in position to attack the fire.

(*d*) Passages or stairways on fire should not be used if rescue from outside can be effected through the window.

(*e*) When using stairways and passages, or crossing rooms, a person should keep near the walls where there is greater support for the floor.

(*f*) If the door of a burning room opens outwards, it is important to control its swing by placing the foot a few inches back from the closed door, so that it may be opened steadily and used as a shield for the body against the outrush of flame and smoke which might otherwise overcome the person about to enter. After this a prone position should be adopted.

Opening the Door of a Burning Room.

(*g*) To move an insensible person, the body should be laid with the face uppermost and the wrists tied together. The rescuer should then kneel astride the body and insert his head through the loop of the arms thus tied, and crawl.

Rescuing an Insensible Person from a Burning Room.

Bringing an Insensible Person Downstairs.

Smothering the Flames when Clothing is on Fire.

To move the body downstairs, it should be placed face uppermost with the head down the stairs. The rescuer should then lead downstairs by crawling backwards, helping the body down with his hands placed under the armpits.

(*h*) If a person's clothing is on fire, he should clap his hands over his mouth, lie down and roll.

If the clothing of another is on fire, the rescuer should make him lie down with the burning part uppermost. He should then approach the victim, holding in front of himself a blanket, rug, overcoat, or any other article suitable for smothering the flames, and cover the flames with the material. The victim should then be rolled until the flames have been put out.

(*i*) To escape from a window without a rope, the proper procedure is to sit on the sill, turn round, lower the body to the full extent of the arms, and then drop with the knees bent, endeavouring to spring slightly away from the walls.

Preparing to Escape from an Upstairs Window.

Dropping from an Upstairs Window.

Precautions to be Taken in Advance

Fire brigades throughout the country have been augmented for the purpose of dealing with incendiary bomb attack. But in spite of this the fire brigade services might be severely strained in the event of a heavy incendiary bomb attack and water for their use may temporarily cease to be available locally owing to heavy demands elsewhere.

It is therefore of vital importance that as many of the public as possible should be in a position to deal with fires on their own property before they become unmanageable; there is no household in which this can be neglected with impunity.

The following are the more important precautions which should be taken in advance in order to deal with incendiary bombs :—

(1) In every household, each adult should be made familiar with the methods of tackling both the bomb and the resultant fire, and duties should be allotted to each person in advance.

(2) The appropriate appliances should be obtained before they are required; the cost of doing so may often conveniently be shared between neighbouring households. Supplies of water, independent of the mains, and of sand or dry earth, should always be ready to hand,

and everyone should know where these supplies and any stirrup hand pump or other appliance which is available are to be found.

(3) Preliminary drill is essential; each person should practise the special duties which he has undertaken to perform, and when he is proficient he should also practise the duties of others, so that each may be interchangeable with the other.

(4) Spaces under the roof, such as attics, in which incendiary bombs are most likely to lodge, should be cleared of combustible material beforehand, and ready access to attics and roof spaces should be provided and made known to the persons concerned.

It should be constantly borne in mind that every incendiary bomb which is promptly brought under control, besides saving water supplies which may be of vital importance for dealing with major fires, averts the risk of a conflagration which may end with the extensive destruction of property and life.

CHAPTER 4.

WAR GASES.

The Nature of War Gases.

The term " gas," in reference to warfare, covers any chemical substance, whether solid, liquid, or vapour, used to produce poisonous or irritant effects upon the human body. A war gas may be used by itself or in combination with other gases so that the presence of any one of them may be masked and its identification made more difficult.

Gases are generally classified in two main categories : non-persistent and persistent.

Non-persistent Gas.

Non-persistent gases are so called because, in whatever form they are released, they are almost instantly converted into gas or smoke which is gradually dissipated by dilution with the atmosphere when the air is in movement. They are effective, therefore, for only a comparatively short time except when there is no air movement, in which case the process of dilution with the surrounding atmosphere is impeded, and the gas remains effective for a longer period.

Some non-persistent gases are visible at the point of release, and wherever the concentration is sufficiently high.

Persistent Gas.

Persistent gases are usually liberated in the form of liquids, and are called persistent because the process of conversion of the liquid into vapour is prolonged; the liquid itself is dangerous to touch, and any area on which it has fallen will continue to give off vapour in dangerous concentrations until the liquid has completely evaporated or been removed or neutralised.

The vapour of persistent gas is normally invisible, and like non-persistent gases, drifts with the wind, gradually becoming dissipated by dilution the further it moves from the source.

Effects of War Gases on the Body.

War gases may also be classified by their effects on the body to form two general categories, non-blister and blister.

Non-blister gases may further be classified as follows.

Lung Irritants (*Choking Gases*).

In dangerous concentrations these gases immediately produce smarting and watering of the eyes, irritation of the throat, and violent coughing and retching (this is specially marked with chlorine and chloropicrin). Breathing strong concentrations of them, even for a very short time, may cause death. Phosgene is one of the most deadly of these gases.

Lung irritants are usually non-persistent gases.

Eye Irritants (*Tear Gases*).

These gases, even in low concentrations, cause extreme smarting and

watering of the eyes. Their effects are only temporary and pass off soon after withdrawal from the affected area or after the respirator is put on. They are effective as harassing agents and might be employed to cause panic and threaten morale.

Tear gases may be either persistent or non-persistent. Their appearance in liquid form is similar to that of blister gas, and they may be mixed with this type of gas in order to mask its presence.

Nose Irritants (Sneezing Gases).

These gases are non-persistent, and consist of solid arsenical compounds liberated as very fine particles in the form of a dust or " smoke." They are generally invisible except near the source, and have practically no smell. They produce intense irritation and pain in the nose, mouth, throat, and chest, which is often accompanied by sneezing and headaches.

These effects may be slightly delayed, and in severe cases may be accompanied by feelings of acute mental distress. As immediate relief is not felt after the respirator has been put on, a false belief may arise that the appliance is failing in its purpose. This, and the nauseating effect of the gas, will create a strong impulse to discard the respirator, which in no circumstances should be permitted. The effects will normally pass off quickly if the respirator has been promptly put on and kept on. Permanent injury is most unlikely to be caused by this type of gas.

Blister Gases.

These gases, whether in the form of liquid or vapour, have the effect of burning and blistering the skin, and may cause injuries to any part of the body which will take long to heal. In both liquid and vapour form they will readily penetrate ordinary clothing. Prolonged exposure to the vapour will cause injury to the eyes and the entry of liquid into the eyes may even cause blindness. If the vapour is inhaled in large quantities or contaminated food eaten, serious internal injuries may be caused. Nevertheless, short exposure to a low concentration of blister gas vapour need have no ill effects.

The two most important blister gases are mustard gas and lewisite. Mustard gas is the better known of these and, unlike lewisite, it produces no immediately noticeable effects on contact or inhalation, and so the need for protection against it may not be appreciated until it is too late. If liquid enters the eye, however, this would immediately be felt.

Contamination.

The word contamination has been adopted to imply the pollution of any substance by war gas in any form, whether solid, liquid, or vapour. This contamination, which is of particular importance in the case of blister gas, is insidious and far-reaching in its effects. Both the liquid and the vapour are absorbed by all porous substances which, when contaminated, continue both to be dangerous to touch and also to give off poisonous vapour after all visible evidence of contamination may have disappeared. Any person touching or walking on a contaminated surface becomes contaminated and would not only suffer injury himself but would carry contamination elsewhere. Likewise contamination may be spread by animals or vehicles.

Foodstuffs which have been subjected to blister gas in any form become agents of contamination, and as such are dangerous; in the worse cases they will have to be destroyed.

Gas Attacks.

One way in which gas can be released from aircraft is by being dropped in

bombs. The casing of a gas bomb is usually of thin material, and may contain a small explosive charge sufficient to burst it and release the gas. The sound of the explosion is only slight as compared to that of a high explosive bomb of similar weight, and so normally it would not be mistaken. On the bursting of the bomb, a dangerous concentration of vapour is produced and a considerable area around the point of burst will also be made dangerous by splashes of the liquid.

Persistent gas can also be released in the form of spray from a container in the aircraft. From a low altitude the spray of liquid gas would be heavy, but the area covered by the spray from one aeroplane would be limited to a comparatively narrow zone corresponding to the path of flight and the direction of the wind. Spray from high altitudes would fall upon a much larger area, but owing to its fineness when it reaches the ground it would be of little effect except when it fell directly on to human beings.

Behaviour of Gas.

The effectiveness of gas is markedly influenced by the characteristics of the area in which it is used, and by the weather conditions prevailing at the time.

Unlike coal gas, war gases are generally heavier than air, it being an important requirement that they shall remain near to the ground where they will be effective and that they shall not be too rapidly dissipated by dilution. Consequently they will normally tend to remain longer on low-lying ground in hollows such as the basement areas of houses, where, to a large extent, they will be sheltered from the dissipating effects of the surrounding air movements.

The principal weather conditions affecting the behaviour of gases are wind, temperature, and rain.

The effect of wind is to carry gas along with it and to accelerate the rate of dispersal. In the case of a persistent gas, the liquid continues to give off dangerous vapour, but the local concentration is lower than it would be in the absence of wind. In built-up areas the free movement of air is to some extent restricted, and consequently gas will tend to remain in these areas longer than elsewhere.

Temperature chiefly affects persistent gases. In warm weather the danger from vapour is increased. If it is sufficiently cold, the liquid will freeze and become solid; there will be little danger from vapour while the gas is in a frozen condition, but in the case of blister gases direct contact with the frozen liquid, or with any contaminated object which is frozen, will still produce skin burns.

Light rain has little effect upon gases, but heavy rain tends to wash gas out of the air, and to wash away and destroy any liquid gas lying upon the ground or other exposed surface.

Non-persistent gas is thus most dangerous when used in calm, dry weather, and persistent gas in dry weather with a high ground temperature and a light breeze; and the danger of both is further increased in a built-up area.

Where there is any movement of air, the areas affected by the gas will be downwind from the point of burst. It is most important, therefore, that persons who find themselves in the open in the presence of gas should immediately make their way diagonally upwind, so as to reach an area of safety beyond the point of release. They should, of course, not walk towards

the point of release where the concentration will be greatest, but move laterally out of the path of travel of the gas.

Respirators for the General Public.

Respirators have been issued by the Government to the whole population. They are the property of the Crown, and as such they may not be maltreated or used for any purpose other than that for which they are intended. It is essential that they shall be worn by everyone who comes within range of war gases dropped by the enemy except those within gasproof shelter.

These respirators will give protection to the eyes and lungs under any conditions likely to arise from the use of any war gas in air raids. None of them is designed to protect the wearer against domestic and other noxious gases which are not used in warfare.

There are three principal types of civilian respirator designed to suit the different ages of wearer. They are the General Civilian Respirator, the Small Child's Respirator for children from about 4 years down to 18 months, and the Anti-gas Helmet for Babies, designed for infants in arms.

The Civilian Respirator.

Description. This respirator has a window of non-inflammable transparent material let into a facepiece of thin sheet rubber which covers the eyes, nose, and mouth, and which is held in position by head-harness. To this facepiece is attached a container which holds activated charcoal to absorb gases from the incoming air, and a filter to prevent the passage of the fine particles of poisonous smokes; the standard of protection against these smokes is now being improved by the fitting of an additional filter known as Contex. Those areas in which Contex filters have not already been supplied will receive them in due course. The local authorities will notify the public when they are available. The fitting of Contex should be carried out only by wardens or other A.R.P. officials.

Thrusting the Chin into the Civilian Respirator.

Adjusting the Civilian Respirator.

Back of the Head with Respirator in Position, shewing central position of buckle.

Air is drawn in through the container, and the exhaled air is prevented from passing back through the same channel by a simple non-return valve consisting of a flat rubber disc attached to the inner end of the container. The exhaled air forces its way out by lifting the thin rubber of the facepiece at its edges, so that a separate outlet valve is unnecessary.

The facepiece of this respirator is provided in three sizes—" Small," " Medium," and " Large "—and the size is marked on the head-straps, or moulded on the brow of the facepiece. The same container is fitted to all sizes.

The " Small " size of the civilian respirator will normally fit a child from 4 years upwards, but in many cases it may be found that a child is sufficiently developed below this age to be likewise accommodated.

A stout cardboard carton is provided, and when not in use the respirator should always be kept in this or in one of the types of carrier referred to later.

Putting on. Before putting on the respirator it is first necessary to stop breathing and remove any headdress. The respirator should be held in front of the face by each of the side straps with the thumbs under the straps; the chin should be thrust into the facepiece, the straps being drawn over the head as far as they will comfortably reach. The breath should then be released in order to expel any gas inside the facepiece, and normal breathing resumed. The headdress may then be replaced.

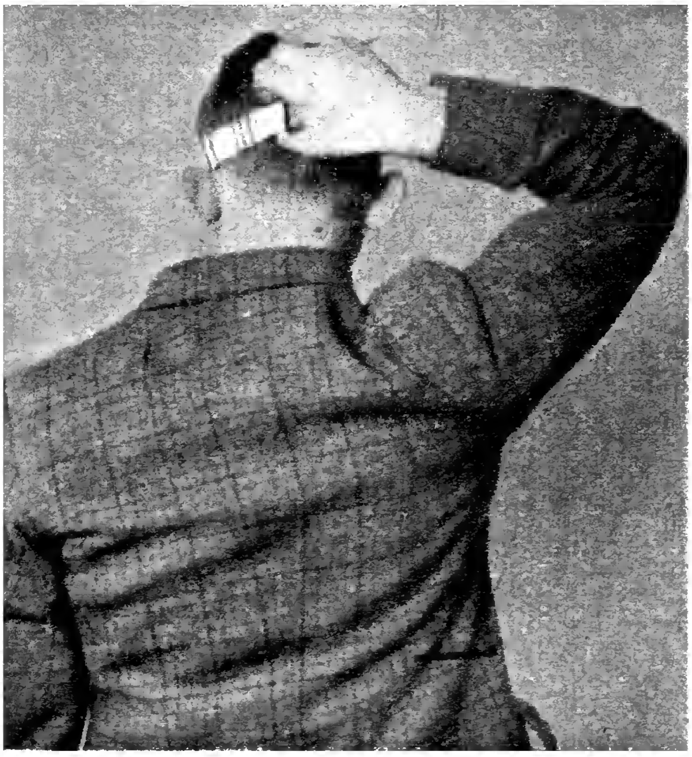
Spectacles or pince-nez must always be removed before the respirator is put on since they will interfere with the fit and so admit poison gas.

Adjusting. If the respirator is properly adjusted it should be quite comfortable in use, and provide a gastight fit in all positions of the head. If the rubber facepiece is stretched too tightly it will be uncomfortable because of the pressure on the face and the undue resistance to the exhaled air, which must pass between the rubber facepiece and the face, usually at the cheeks. This resistance to breathing will be found most exhausting, and the defect may be overcome either by the fitting of a larger size of respirator, if it is not already the large size, or by the proper manipulation of the adjustable head-harness.

Testing Fit. If the fit is too loose or incorrect, air may be breathed in without passing through the purifying materials held in the container. This can be tested by holding a flat surface, such as a piece of paper or cardboard or a cork mat, against the outer end of the container, and attempting to inhale. If the intake of air is found to be impossible and the facepiece is sucked in against the cheeks, it can be assumed that a gastight fit is provided.

If Contex has been fitted, a piece of stiff paper or card will not seal the holes, because the end of the Contex is corrugated. A thin cellophane jam jar cover may be used instead, or a piece of very thin, good-quality paper.

Size. The correct size of respirator can be judged by the position of the transparent window in relation to the eyes, which should be on a line about midway between the upper and lower edges of the panel. If the eyes are considerably above this line, the respirator is too small; if they are much below, it is too large.



Preparing to Remove the Civilian Respirator.

Checking. In making tests, and always when wearing the respirator, it must be ensured that the edges of the rubber facepiece are not doubled under and that the straps are not twisted. The buckle should be centred at the back at the crown of the head and the facepiece should be straight on the face with the two side straps horizontal.

Women should adjust their hair so that it does not lie under the facepiece, and it may also be necessary to remove hairpins to ensure a safe and comfortable fit.

Securing. When the correct adjustment of the head-straps has been found, the safety-pins provided should be used to ensure that it is maintained. In the case of children, to make sure that the respirator remains comfortable,


Small Child's Respirator.

adjustments may be necessary from time to time, in accordance with the growth of the child.

Removal. To remove the respirator, the thumb should be inserted under the buckle at the back of the head and the straps drawn forward over the top of the head and then in a downward direction. Any other method may cause damage to the facepiece, and must not be attempted.

The Small Child's Respirator.

Children do not, as a general rule, take well to wearing respirators, and the difficulties their parents and guardians may have in this connection, together with the other dangers of air raids, should be avoided where possible by the evacuation of children from the more vulnerable areas. The possibility of air raids, even in the comparatively safe reception areas, cannot, however, be wholly discounted, and the Government have therefore made a general distribution of the Small Child's Respirator.

Description. An attempt has been made in the design of this respirator to make it as acceptable as possible to young children. The colours have been made attractive; it has been made as light in weight as possible; the head-harness will not weaken in use, is gentle in its pull on the facepiece, and is so designed that it prevents the respirator from being easily pulled off. Since the child breathes much less air than an adult, a less bulky and lighter container than that of the ordinary Civilian Respirator has been included, and this is screwed into the facepiece.

The container causes only a negligible resistance to the child's breathing, and the air breathed out passes out of the facepiece through a soft rubber valve which opens freely under the pressure of the breath. Contex may be added to this container also.

The facepiece is made of soft rubber so that it readily takes the shape of the child's face and makes close contact with the skin. Eyepieces are fitted in place of the transparent window found in the Civilian Respirator.

Putting on and Removal. The respirator is put on in the same way as the adult respirator. Many children quickly learn to put it on themselves if they are shown how to thrust the chin forward into it. If it is put on by a second person it is better to do so from behind, with the back of the child's head resting against the chest of the adult, so that the child's neck is supported against the action of pulling the spring harness over the head. To remove the respirator, it should first be unhooked at the back of the head, and the

instructions for putting it on then reversed, the movements following closely those given for the removal of the adult type.

Adjustment and Testing. The head-harness is suitable for all sizes of heads without adjustment. If the respirator is properly put on with the harness secured by means of the hook and eye at the back, the fit of the respirator is automatically ensured if the child's face is of the correct size for it, and the close contact between the rubber and the face can clearly be seen. It is unnecessary, therefore, to test for gas-tightness, as suggested in the case of the Civilian Respirator, and this is not recommended.

There is only one size of Small Child's Respirator. If there is difficulty in stretching the head harness over the head, or the eyes are unduly high in the eyepieces, this type of respirator is too small for the child, and a small Civilian type should be used. If the facepiece of the Small Child's Respirator puckers at the edges or is loose on the face, or the eyes are unduly low in the eyepieces, the child is too small for this type, and the special appliance, known as the Baby's Anti-Gas Protective Helmet, should be used.

The Baby's Protective Helmet.

Infants in arms up to the age of about 18 months and young children who show a marked distaste for the Small Child's Respirator, or are otherwise temperamentally or physically unfitted to wear this type, may be accommodated by the Baby's Helmet.

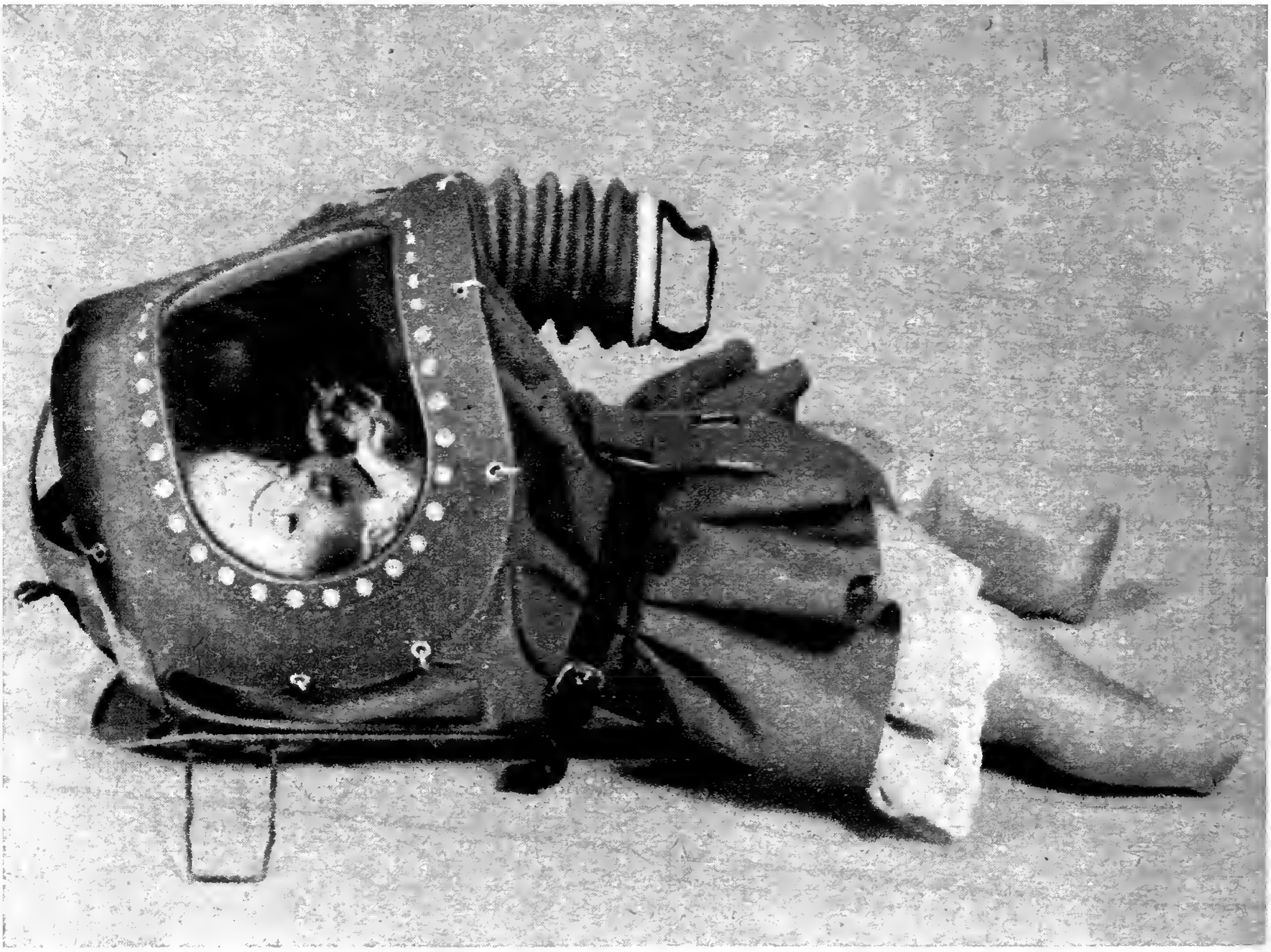
Description. It consists of a hood, made of impervious fabric and fitted with a large window, which encloses the head, shoulders, and arms, and is closed around the waist by means of a draw tape. A baby, when in it, is thus able to get its hand to its mouth. The hood is surrounded by and fastened to a light metal frame, which is lengthened on the underside and fitted with a tail-piece which can be adjusted by means of two screws turned with a coin, so as to form a support and protection for the baby's back. The length should be such that the baby's face is opposite the middle of the window. It can be made extra long, if required, by overlapping the tailpiece on the last two screw holes only and using an extra screw and nut in the hole which has no fixed nut. A spare screw and nut for this purpose will be found on the domed top of the frame.

The tailpiece is turned up at the end to form a seat which prevents the occupant from slipping out of the hood. The baby is made secure in the helmet by means of a T-shaped supporting strap connected to the end of the tailpiece. The metal frame and supporting strap may be varied in length to suit all sizes of babies and children up to about 5 years of age.

The hood is padded on the underside where the baby rests. Padding has been omitted from the tailpiece since babies are likely to soil any padding in this position. If required, mothers can supply some washable padding, e.g., a folded towel or napkin, for this part of the frame.

Folding legs are provided on the metal frame for use when the helmet is not being carried or nursed. The legs will prevent the helmet from rolling over if it is laid down with a child in it, and they are for use when a baby is being put into the helmet.

Air is supplied to the inside of the hood by means of a rubber bellows placed conveniently for the right hand. The air passes through a container which removes all poison gas from it, and enters the hood at the top through a specially shaped orifice which deflects the air upwards so that it sweeps out all vitiated air from the hood and also prevents the stream of air from blowing directly on the baby's head. A slow and steady rate of pumping of about 40 strokes a minute is adequate for keeping out gas and supplying enough purified air even for a child of 4-5 years of age. The space in the hood is large



Baby's Anti-Gas Helmet.

enough to allow pumping to be stopped for several minutes if required without causing discomfort. When pumping, the operator should be careful not to obstruct the intake holes which lie in the disc at the movable end of the bellows under the palm of the hand.

There is no limit to the time during which a child may remain in the helmet if steady pumping is maintained.

Contex may be fitted to the container in a baby's helmet, but only by properly qualified persons. The helmet should never be taken to pieces by an unskilled person because there is a risk of its being reassembled wrongly, so that it will not protect the baby against gas.

Fitting and Operation. To put the baby into the helmet it is necessary to proceed as follows :—

(1) The wire legs of the helmet should be opened and clicked back.

(2) The helmet should be laid down with the skirt of the bag open and the top turned back over the window. The wide strap attached to the turned-up end of the metal tailpiece should be out of the way, so that the baby will not lie upon it.

(3) The baby should be placed in the helmet so that its seat rests in the curve of the tailpiece with one leg on each side.

(4) The skirt should then be pulled down over the baby and it should be ensured that both arms are free and are put up inside the bag before the tape is tied. The ends should then be drawn snugly, but not too tightly, around the infant's waist, and finally finished off by tying in a bow.

(5) The supporting piece should now be brought up between the legs and the ends of the canvas strap attached to the buckles on each side of

the frame so as to hold the baby firmly in place. If the frame is being used in one of the shorter positions of adjustment, it may be necessary to shorten the supporting piece in order to hold the child securely. This may be done by folding down the top end either once or twice, as required, and passing the ends of the canvas strap out through the metal slots.

(6) When the baby has thus been safely secured in the helmet, the bellows should be operated. First, at least twelve sharp strokes are required to clear out the air in the helmet, and then a slow and steady rate should be maintained.

The baby in its bag can be nursed on the lap or carried in the arms in the normal way; if it must be taken some distance, the legs of the frame should be folded underneath, and a wide shawl used as a sling to support the baby from the mother's shoulders.

It is desirable that the complete drill described should be practised both in daylight and in darkness, and when the parent or guardian is herself wearing a respirator.

Since the growth of infants is sometimes rapid, frequent adjustments may be necessary to the length of the helmet in order that the child may at all times be comfortable and fully protected.

The carton in which the baby's helmet is supplied is only large enough, with the normal method of packing, to take the helmet with the tailpiece unextended, and the extension of the tailpiece to keep pace with the baby's growth will therefore present a problem from the point of view of packing. It is desirable that the helmet should be kept with the tailpiece extended to the proper length, and at the same time it is important to avoid mutilation of the carton, in view of the need for economy of cardboard. The following method of packing, which will be demonstrated to parents of babies by wardens, should therefore be used when it is necessary to extend the tailpiece of the helmet.

The flap of one end of the carton should be turned down inside the carton and the helmet inserted upside down in the carton with the extended tailpiece sticking out over the end of the turned-down flap. The other end-flap should then be closed and the side-flaps closed over the top, a piece of string being tied round the whole carton. The carton will then enclose the whole helmet and keep it reasonably free from light and dust, even though the end of the tailpiece protrudes at one end.

Use and Care of Respirators.

On all occasions when gas is present and a gas-protected room or refuge is not available or has to be vacated, the respirator must be put on without delay. In order to ensure this it is necessary to take the respirator on all journeys on which the wearer will be more than five minutes away from the place where it is ordinarily kept. It is also necessary to practise putting on and taking off the respirator both by daylight and in darkness, so that this may be done when required with the minimum delay. Furthermore, it is desirable to become accustomed to the wearing of a respirator, and to be sure that the respirator is comfortable in practical use over a period of time, since it must not be removed for adjustment in the actual presence of gas.

After use, whether for practice or otherwise, the inside of the facepiece or bag should always be wiped dry before the respirator is returned to its carrier. If wet from exposure to rain the outside should also be wiped.

Occasionally it may be necessary to clean the appliance more thoroughly. This may be done by means of a small sponge or soft cloth dipped in a rich solution of toilet soap and lukewarm water and wrung out thoroughly before

Testing Rubber of Mask.

swabbing. The appliance should then be sponged in the same way with clean water, well wrung out. Great care must be taken, however, to prevent the entry of any moisture into the container, since this will damage its contents and impair its efficiency.

Respirators of all types should always be put away quite dry. Those of the general civilian type should be folded in such a way as to prevent kinking or unduly bending the delicate transparent window. All respirators should be kept in a cool, dry place, away from a strong light or heat; they should never be left in front of a fire, near a radiator, or in the sun. Respirators other than the baby's helmet should not be carried or hung suspended from the straps, nor should they be confined to their carrier for long periods without being taken out periodically, since this may affect the fit through prolonged distortion of the facepiece.

Occasional inspections should be carried out by the holders of respirators to make sure that they are in good condition, but it must be stressed that any undue tampering with the delicate sections is likely to do more harm than good.

The following are a few general points, applicable in particular to the general civilian respirator, which should be looked at occasionally; if any faults are disclosed the local warden should immediately be consulted :—

The transparent window is the most easily damaged part, and cracks or weaknesses should be looked for by holding before a light. The stitching round the edges must be secure. At the same time the thin rubber of the facepiece can be tested for punctures, tears, and signs of perishing, by gently stretching it so that a section of an inch is expanded to about 2 inches. Chafing caused by friction against the sides of the carrier, especially where this is not of the Government pattern, is almost always responsible for any weaknesses detected here.

The thin rubber disc fitted centrally to the valve pin on the inside end of the metal container should be soft, pliable, and flat. If it is concave it should be taken off the pin and reversed. If it has hardened, it should be renewed.

The rubber band joining the facepiece of the general civilian respirator to the metal container should be perfectly fresh and elastic. If it shows cracks, it is perishing and should be renewed. Stitching generally should be sound. The container of the Small Child's Respirator screws into the facepiece; it should be ensured that this is tightly done up.

Examining Rubber Disc.

A severely dented container, or one which is perforated, or into which moisture has entered (as may be detected by the discolouration of the white filter material visible through the air holes at the outer end of the container), should be further examined by a competent official of the local A.R.P. organisation.

In all cases, whether further advice or a new part of a respirator is required, the local warden should be consulted.

Treatment to Prevent Misting of Eyepieces.

When respirators are worn, moisture from the breath will condense inside them and vision will tend to be obstructed by misting of the transparent window or eyepieces. This can be avoided by the application of a thin film of toilet soap lightly smeared with the finger upon the inside of the window.

It is suggested that this treatment should always be applied on putting the respirator away after use so that it will be immediately ready to put on when required. If the respirator is not worn, the treatment remains effective for a week, after which time the window should be lightly sponged and dried, and a fresh treatment applied.

Carriers for the Civilian and Small Child's Respirators.

Respirators should be kept and carried in the cardboard carton provided for them. They should be inserted with the container leading; the container of the Civilian Respirator should be inserted into the recess at the bottom of the carton, the facepiece being folded over so that the transparent eyepiece lies evenly on the top of the container at full length, without any deformation.

In order to preserve the carton and to protect it from rain, it is recommended that it should be enclosed in a waterproof satchel, or other durable form of cover, fitted with a suitable shoulder strap. The satchel should be so designed that rain cannot enter between the flap and the body, and so that access to the respirator is impeded as little as possible. For instance, the flap

should be secured by means of press studs and not by tie-tapes, which might be difficult to untie in a hurry, and the flap of the satchel should be positioned so as to coincide with the lid of the carton.

No other article of any description, such as first-aid outfit, electric torch, anti-gas ointment, lipstick, face-powder, etc., must be carried in the carton with the respirator. If, for convenience, it is desired to combine carriage of such articles with that of the respirator, provision must be made for them in separate pockets or compartments in the satchel.

If no satchel or cover is used, the cardboard carton can be strengthened at the bottom joint, at the corners and the hinge of the lid with adhesive tape. The carrying cord should be threaded outside the bottom of the carton to prevent the bottom slipping loose. The water-resistance of the carton can be improved by painting it, on the outside only, with any good-quality oil paint. In rain the carton, if not provided with a waterproof cover, should be carried under the coat or mackintosh.

Alternative forms of carrier to the official carton may be purchased, but great care must be exercised before using such alternatives that no damage or deterioration of the respirator is likely to ensue. The following general principles must be observed when choosing a carrier :—

(1) The carrier must be designed and made of material which is sufficiently rigid to protect the respirator from being crushed, e.g., in a dense crowd, or against a seat in a moving omnibus, or if the carrier is dropped to the ground.

(2) The carrier must have a smooth interior with no inward projection, such as a rim, lip, or sharp rivet head, which would either scratch or catch against the edge of the eyepiece during insertion, withdrawal, or ordinary carriage of the respirator.

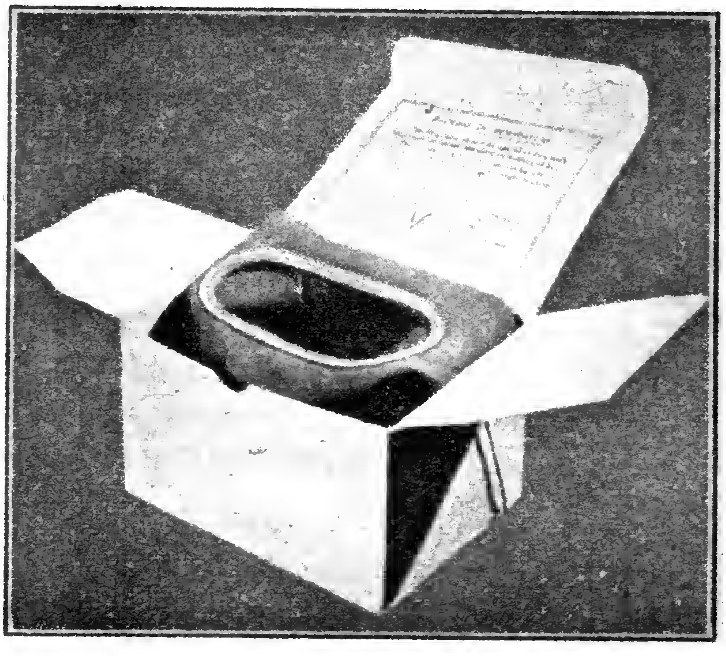
(3) The respirator must not be a very loose fit in the carrier, so that it rattles and gradually abrades the rubber around the container.

(4) The carrier must be of such a size and shape that it neither causes nor allows gross distortion of the facepiece, e.g., it must not require the facepiece to be turned inside out, or be such that the container either rests or can become inverted on to the facepiece.

(5) If the carrier forms part of a hold-all, e.g., if combined with a shopping bag or a handbag, it must allow of direct and rapid access to the respirator without the necessity of first removing other articles.

Gasproof Accommodation.

In view of the universal provision of respirators, gasproof accommodation in the ordinary house is not essential, but where it is possible to do so it is an advantage to make the refuge or shelter gasproof. The main principle to be observed in this connection is the blockage of all sources of draught into the room. Such places as the fireplace or ventilator gratings in the walls



Civilian Respirator Correctly Packed in Carton.

encourage draught, and consequently it is difficult to prevent the entry of air (and gas, if present) under doorways, between the floorboards, through cracks in walls, and, where windows have not been bricked in, between frames and window, unless these natural ventilators are first blocked. If this is done, quite simple means, such as pasting layers of brown paper over cracks in walls and flooring and over gratings and plugging other places with tightly rolled newspaper or pieces of felt, will answer the purpose adequately, and no undue expense or preparation is consequently necessary.

Whether or not a gasproof refuge is available, the respirator must always be taken there during air raids, since even the distant effects of blast from H.E. bombs may destroy the gas-tightness of the chamber, and if gas were used the respirator would then immediately be required.

Where the provision of gas-tightness in a refuge renders the room otherwise untenable for ordinary use, and so presents a source of difficulty or embarrassment to the householder, it is suggested that the materials required for the purpose be immediately obtained and left in the refuge, but that they need not be applied until it is clear that the enemy propose to use gas against this country in air raids or they have already done so. At such a time there should be no further delay in completing the preparations.

Generally, when gas is announced in an area by the warden's rattle, if no gasproof accommodation is available, or the gas-tightness of a refuge has been destroyed by the effects of the raid, respirators should immediately be put on. Normally they need be kept on only until the warden's handbell announces the region " All Clear " and free of gas. But if gas has penetrated the building, it will be necessary to clear this by adequate ventilation, employing means of forcing the air to circulate freely throughout the building, so that the premises can be made safe for normal habitation without the use of respirators. In spite of the sounding of handbells, therefore, respirators, when worn, should not be taken off until it is certain the air is free from gas. The purity of the air can be tested by lifting the side of the facepiece of the respirator by inserting two fingers at the cheek and gently sniffing the unfiltered air; a fairly full breath should be taken in before the facepiece is lifted, and vigorously expelled after the test has been made, in order to blow any contaminated air from the respirator. If there is any doubt as to whether gas is present or not, the respirator should be kept on until this doubt can be removed. A rough guide to the smells of various gases is given in the Appendix " Table of War Gases "; they cannot be implicitly relied upon, however, since the presence of other constituents in existing known gases may alter their smell and so confuse detection. Any unusual smell should be regarded with suspicion, and where any doubt is felt it is recommended that the warden be consulted and asked for assistance.

Protection of the Body Against Blister Gases.

Protection of the body against blister gas, when this is present, may best be ensured by remaining under cover after a gas alarm has been sounded, until such time as the ringing of handbells by wardens pronounces the area " All Clear." There may, however, be cases in which contamination by misadventure may take place or be suspected, and it is necessary, therefore, to know the way in which the dangers might arise and the immediate steps necessary to overcome or to minimise the possible consequences.

The two principal blister gases are mustard gas and lewisite, and further information concerning them, including indications of the way in which their presence may be recognised, are given in the Appendix.

The respirator container will prevent the passage of the vapour of mustard gas and lewisite, and will thus protect the face, eyes, and

respiratory system, but the remainder of the body will be liable to injury by exposure to the liquid or vapour. Ordinary clothing is of some value in that it delays penetration by vapour, or (to a less extent) liquid, and therefore the full effects of any contamination are not immediately produced on the skin. If such clothing is removed quickly and the skin thoroughly washed with warm water and soap, injury may be avoided, or very much reduced.

This procedure is intended to be followed by persons who are contaminated, or who suspect they have been contaminated, and are near their own homes or places of work, so that they can treat themselves promptly. Where, however, there might be delay, the outer clothing should be removed at once, and treatment sought at a public First-Aid Post. Here it will be possible for the person to wash, to put on clean garments, and to receive such first-aid treatment as his case may demand.

Persons who intend treating themselves in their own homes must remove their boots and outer clothing before entering the house, so as to avoid spreading the contamination and causing further casualties. Such discarded clothing and boots should be placed outside the house in a dustbin or other metal container with close-fitting lid, and steps taken at once for their removal and decontamination in accordance with local arrangements.

Decontamination of Contaminated Articles of Personal Apparel.

Ordinary Clothing.

Articles of ordinary clothing, such as overcoats, hats, coats, trousers, dresses, etc., which have been contaminated with vapour, should be hung in the open air for at least 24 hours. If the clothing still smells of the gas after 24 hours it should be placed outside the house in a container described above.

Light dresses and underclothing contaminated with vapour should be washed with soap and warm water, after preliminary airing, for at least 15 minutes.

Clothing which is, or is suspected of being, contaminated with liquid mustard gas should not be decontaminated at home, but should be placed outside the house in a container as already described.

Leather Boots and Shoes.

The decontamination of leather boots or shoes is a difficult problem, and all possible care should be taken to prevent their becoming seriously contaminated, by avoiding, for example, stepping into splashes or pools of liquid gas.

Persons who have walked through contaminated areas should in any case examine the soles and uppers of their boots to make sure that the boots are not contaminated with liquid mustard gas, taking care while doing so that they do not contaminate their hands. If any trace of mustard gas can be seen or smelt, the boots must be removed at once and taken as soon as possible to the appropriate place for treatment; meanwhile they should be left out of doors and not worn again until decontaminated.

Respirators.

Respirators which have been worn in blister-gas vapour should be thoroughly aired before being put away. If there is any sign of liquid contamination, the respirator must at once be returned to the appropriate quarter of the local authority, where another will be issued in its place.

CHAPTER 5.

SIMPLE FIRST AID

Introductory.

A complete organisation has been set up to deal with all types of injury caused by air raids, consisting of First Aid or Stretcher Parties, an Ambulance Service, First Aid Posts, and specially earmarked Hospitals.

Any injured person requiring treatment should go, if he is able, to the nearest First Aid Post. For those more seriously injured, First Aid Parties will render first aid and arrange where necessary for removal to a first-aid post or hospital.

There may, however, be occasions after heavy raiding when the services of first aid parties are not immediately available at all places where they are required. Often simple measures, if quickly taken, will save life; for example, in cases of extreme hæmorrhage (bleeding) or of true asphyxia (suffocation). Accordingly some of the elements of First Aid are described in the following pages, in order to enable those available at the scene of damage to assist the wounded while trained parties are on their way.

Wound Shock.

Every injury is followed by a condition known as Shock or Wound Shock, which is a failure of vitality varying in degree from transient faintness to extreme and dangerous prostration. In air raid cases Shock is likely to be very marked.

The condition can be divided into two stages, Primary Shock, which immediately follows the injury, and Secondary Shock, which may develop later as a result of excessive pain or bleeding or cold for a prolonged period or through clumsy or incorrect handling. Primary Shock may lead to Secondary Shock, if proper care is not taken, and this, if allowed to develop, may be dangerous to life.

Primary Shock can be treated, and Secondary Shock to a large extent prevented, by simple means :—

(i) Pain must be relieved ; for example, by gentle adjustment of the casualty's position, or by suitable support to the injured part before removal.

(ii) The patient must be protected from chill, since in cases of Shock body temperature falls rapidly. Unnecessary removal of clothing should be avoided, and the casualty should be wrapped in blankets or coats, with at least one layer between him and the ground.

(iii) Loss of blood must be checked.

(iv) Fractures or badly injured limbs or joints should be secured.

(v) Gentleness and smoothness are always essential in handling, lifting, and removing the patient.

(vi) Warm sweet drinks, such as sweetened tea, are of advantage to patients suffering from Shock, but it is dangerous to give any drink

or food to an unconscious person, or to one who has a wound in the belly, or who complains or gives evidence of abdominal pain.

Hot water bottles are useful for protecting casualties from chill. They should be placed where they can best warm the circulating blood, for example, between the body and outspread arms, or the upper part of both thighs, since in each of these regions main arteries are relatively close to the surface and the warmth is circulated through the body by means of the blood stream. In doing this, care should be taken, by wrapping the hot water bottles in woollen or other material, to avoid burning the patient. They should never be laid directly on the bare skin.

Where a domestic hot water bottle is not available, an ordinary glass bottle, or similar container, wrapped in any piece of material or article of clothing, would make a suitable substitute. If an ordinary glass bottle is used, it should not be filled with boiling water, especially if the bottle is cold, as it may thus become cracked and subsequently break ; care should be taken in moving the casualty to prevent the bottle being broken and the casualty cut.

Bleeding (Hæmorrhage).

Profuse bleeding from a large artery immediately endangers life. Loss of blood is in any case one of the main causes of both Primary and Secondary Shock, and even the continued oozing of blood from an extensive area of the body may lead, if neglected, to collapse and finally to death.

Types of Hæmorrhage.

Hæmorrhage may be either external, in which case it is easily discovered, or it may be internal, caused by injury to blood vessels inside the body, from which the blood escapes into internal organs or cavities of the chest or abdomen. In the latter case, no blood is visible externally, unless it is coughed up or vomited.

Symptoms of Hæmorrhage.

The signs and symptoms of severe uncontrolled bleeding, either external or internal, are as follows :—

(i) There is rapid loss of strength, accompanied by giddiness and faintness, especially if the patient is raised to a sitting or standing position.

(ii) The face and lips become pallid, and the skin cold and clammy.

(iii) Breathing becomes hurried and laboured, and may be accompanied by yawning and sighing.

(iv) The pulse quickly becomes so weak and rapid as not to be felt at the wrist.

(v) The patient becomes thirsty.

(vi) He may become restless and throw his arms about or tug at clothing round the neck ("air hunger"), unlike a patient suffering from Shock without serious bleeding, who will lie very still.

(vii) Finally, the patient may become wholly unconscious.

If these signs are observed, but no external cause is apparent, the case should be regarded as one of severe internal hæmorrhage.

Treatment of External Hæmorrhage

Blood escapes with less force if the patient is sitting and still less if he is lying, and the position of a casualty with external hæmorrhage should be adjusted accordingly. Except in the case of a fractured limb, the bleeding part should, where possible, be raised, to lessen the flow of blood to it. Firm, even bandaging with a pad of cotton wool or other soft material placed over the wound will normally help to check the bleeding.

In the case of a severely lacerated limb, bleeding should be dealt with by bandaging over a splint even though no fracture has been definitely recognised.

Treatment of Internal Hæmorrhage.

Internal hæmorrhage can only be treated on the operating table. The first aid urgently needed is warmth, extremely gentle handling and lifting, and rapid but smooth removal for surgical attention. Where there is even a suspicion of internal hæmorrhage, the patient should on no account be allowed to eat or drink.

Wounds in the Abdomen.

Casualties with wounds in the abdomen are more comfortable and less liable to further damage in moving if they are placed on the back, with the abdominal wall relaxed by bending the knees over a box, haversack, or rolled coat, and with the head and shoulders slightly raised. If any organs protrude, no attempt should be made to replace them, but they should be covered with lint, a soft towel, cotton wool, clean soft flannel, or similar material for protection, and the covering secured firmly, but not too tightly, with a broad bandage. It is desirable for the material used in contact with the wound to be wrung out of warm water to which, if it is readily available, table salt may be added in the proportion of one teaspoonful of table salt to a pint of clean hot water. On no account should a patient with an abdominal wound be given anything to drink.

Fractures.

Simple Fractures.

When bone is fractured (broken) and the surrounding flesh is undamaged, the injury is a simple fracture.

Compound Fractures.

When bone is broken and in addition there is a flesh wound at the site of the fracture, the fracture is said to be compound.

Complicated Fractures.

When bone is broken, and in addition there is damage to some important organ, the injury is a complicated fracture.

The following signs and symptoms may be present in cases of fracture :—

(i) Pain at or near the point at which the bone is broken.

(ii) Loss of power of movement in the affected limb.

(iii) Swelling around the part affected.

(iv) Deformity, the limb falling into an unnatural position and having an abnormal shape. It may be shortened by the over-lapping of the broken ends of the bone.

(v) Irregularity : if the bone is close to the surface, a bump may be felt at the break and, if the fracture is compound, the bone may be exposed and visible.

Simple First Aid Treatment of Fractures.

(i) The first object is to prevent further damage being done by injudicious movement or by careless handling, and especially to avoid converting a simple fracture into a compound one, or causing an uncomplicated fracture to become complicated.

(ii) Unless the circumstances are such that danger to life is threatened, or that there is danger of further injury being caused if the patient is not immediately removed, the fracture should be attended to where the patient lies. The injured limb should be secured by splints or in some other way, and then the patient may be carefully moved.

(iii) If there is severe bleeding which is immediately endangering life, this must be controlled first.

(iv) Warmth and air are required to guard against shock which will certainly accompany the fracture. Blankets or coats should be wrapped round the patient, care being taken not to disturb him unduly. Merely covering the patient is often not enough to prevent him from becoming chilled.

(v) The limb should be placed in as natural a position as possible with great care and without using force. In the case of a compound fracture with a protruding fragment of bone, no attempt must be made to replace it.

(vi) If there is no material for splinting, a fractured leg may be secured by careful bandaging to the opposite leg, or a fractured arm by bandaging to the trunk.

(vii) Splints, real or improvised, must be sufficiently firm, and long enough to keep the joints immediately above and below the fracture at rest. The bandages must be firm, but not so tight as to interfere with the circulation of the blood.

(viii) Splints should be put on over the clothing and should, if practicable, be padded in places where there is risk of rubbing, or where there would be gaps between the splint and the body. Any suitable material which is available, such as clothing, handkerchiefs, or newspaper may be used as padding.

Improvised Splints.

Serviceable splints may be improvised from such things as laths from a venetian blind, from rifles, walking sticks, pieces of wood or cardboard, rolled up linoleum or newspaper, and a number of other articles, provided that the resulting improvisation gives sufficiently rigid support for the limb, and is long enough to prevent movement of the joints immediately above and below the fracture.

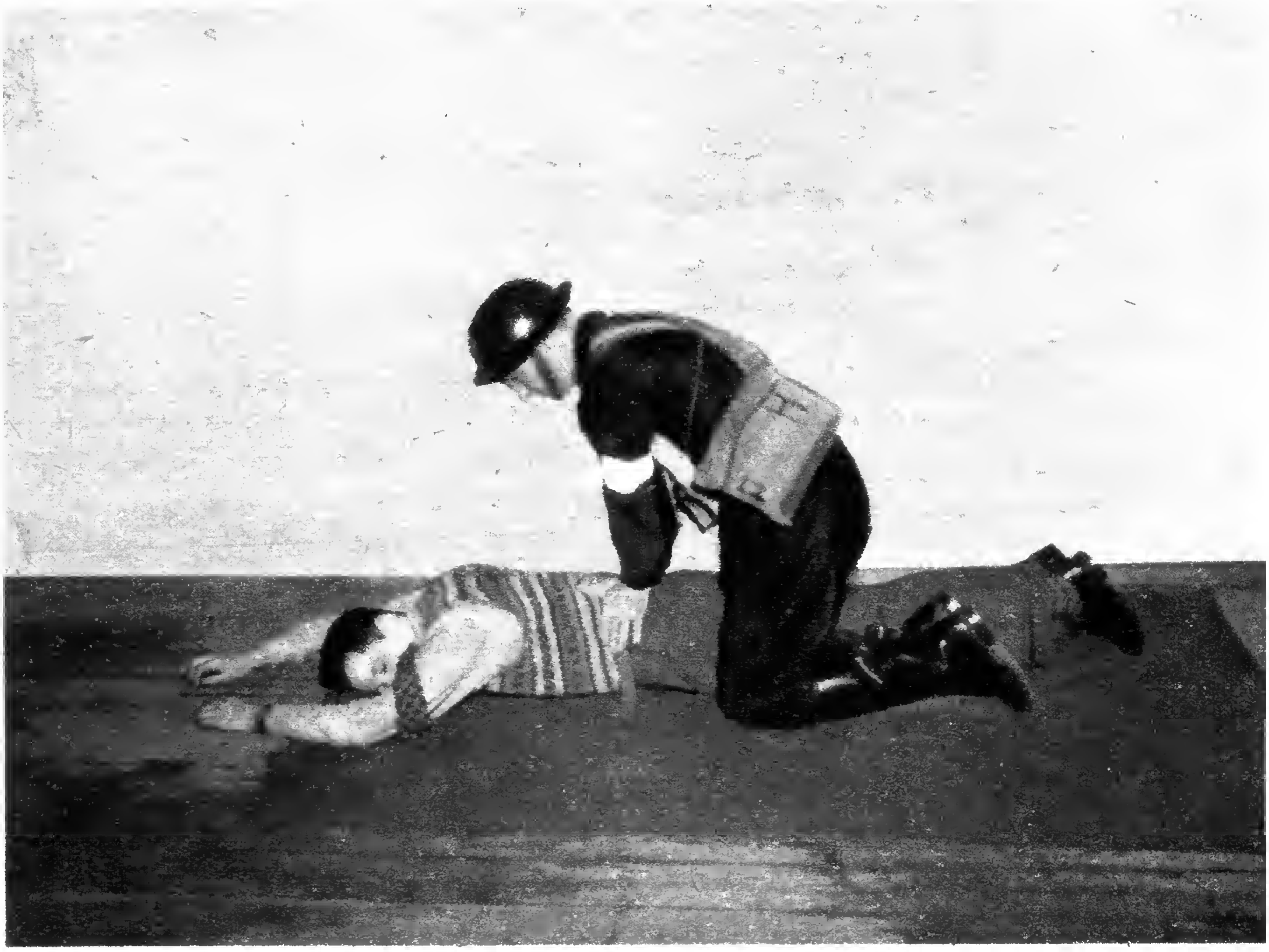
Improvised Bandages for Securing Splints.

Where the proper bandages, such as a triangular bandage, cannot be obtained, scarves, such as those worn by Boy Scouts, or pieces of cloth can be used. Ties, braces, straps, belts, or lengths of rubber tubing may be employed to secure splints or dressings.

Improvised Slings.

Slings may be improvised by pinning the sleeves of the coat to the garment, or by turning up the lower edge and pinning it to the main body of the coat. Improvisation may also be successfully effected by passing the hand inside the coat or waistcoat, which should then be buttoned. Scarves, ties, or belts loosely slung around the neck will also provide support.

Artificial Respiration—Backward Swing.



Artificial Respiration—Forward Swing.

Unconsciousness (Insensibility).

As a general rule, an insensible person should be laid on the back, wrapped in coats or blankets, with the head turned to one side; if he has false teeth, they should be removed. If the face is flushed, the head and shoulders should be slightly raised; if it is pale, they should be kept low. Any tight clothing, especially at the neck, chest, or waist should be loosened. Nothing must be given through the mouth to a person who is partly or wholly insensible. If an insensible person must be moved, smoothness and care are essential.

Suffocation (Asphyxia).

Anything which prevents the body from getting sufficient oxygen will cause a condition known as asphyxia, which, if unrelieved, will lead to insensibility and death.

Common causes of asphyxia under air raid conditions include electrocution; continued pressure on the chest or obstruction of the upper breathing passages, for example, by debris; confinement in a poisoned atmosphere (for instance, in an enclosed space containing domestic coal gas, exhaust fumes, or after-damp); and drowning.

The first action is to remove the cause of the asphyxia, or to move the casualty from the cause, whichever is the more suitable, and then immediately to begin artificial respiration, preferably by the Schäfer method, which is as follows:—

> The patient should be placed face down with his head turned to one side and his arms forward. The helper should kneel beside the patient facing towards the head and should place his hands on the small of the back, with wrists nearly touching, thumbs together, and fingers passing over the loins on either side. He should swing rhythmically backwards and forwards from the knees at the rate of about twelve double-swings per minute, keeping his arms straight, so that his weight presses the patient's abdomen against the ground and forces his abdominal organs against his diaphragm on the forward swing, pressure being entirely released on the backward swing. The pressure period should occupy two seconds and the period of relaxation three seconds; to ensure regularity the rescuer should count evenly up to five on each double swing. This should be continued until natural breathing returns, when the rhythmic swing of the helper should coincide with the patient's respiratory movements.

Artificial respiration may have to be continued for an hour or longer, relays of helpers being employed if necessary.

While artificial respiration is being performed, other helpers should undo all tight clothing and wrap coats or blankets round the casualty.

Removal from Electrical Contact.

In cases of injury due to an electric current, the current should, if possible, be switched off at once. If this is not possible, it is necessary that the helper should himself be protected from becoming electrocuted, and for this reason he must place non-conducting materials between himself and the casualty, and between himself and an earth. Non-conducting materials, which may be available include rubber, linoleum, wood, glass, clothing, or newspaper. They should all be dry.

The injured person may be dragged away from the electric medium with a hooked walking stick or a loop of dry rope; an umbrella should not be used since the metal parts will conduct electricity. Metal and moisture are good conductors of electricity, and therefore the helper should avoid

touching the hands, armpits, wet clothing, nailed boots, or metal equipment of the injured person.

Burns (other than from Gas) and Scalds.

A burn is caused by dry heat, for example by a flame, hot metal, or a strong acid or alkali. A scald is caused by wet heat, for example by steam, boiling water, or boiling oil.

General rules for the treatment of all burns or scalds are :—

(a) Air should be excluded from the affected part as soon as possible. It should either be immersed in water, preferably at body temperature, or covered with clean cotton wool, lint, or soft clean cloths, and then bandaged. These are only temporary measures to meet the situation until suitable first aid dressings are prepared.

(b) If clothing has to be removed great care should be used. If it sticks, it is necessary to cut around the pieces of cloth which adhere to the flesh so as to leave them in position when the garment is removed. If blisters have formed, they must not be broken or punctured, but should as far as possible be protected and kept intact.

(c) Suitable first aid dressings may be made from strips of lint or linen about 2 inches wide ; they should be :—

either (i) soaked in warm strong tea and allowed to dry ;

or (ii) soaked in a lotion made by stirring baking soda in clean warm water. In this case the strips must be kept wet by repeated damping with the lotion which can be poured on over the bandage without necessitating its removal each time. The strength of the lotion should be about 2 teaspoonfuls of soda to a pint of water ;

or (iii) smeared with tannic acid jelly on the surface to be applied to the skin.

The dressings, which should slightly overlap, should be covered with cotton wool or soft cloth and lightly bandaged, and the affected part supported.

In severe or extensive burns, Shock will be marked and will require attention. The patient must be kept warm.

Gas Casualties.

Blister Gas.

If the eyes have been exposed to vapour or liquid gas, they should immediately be thoroughly washed with warm water or with a weak solution of salt or bicarbonate of soda; the strength in each case should be about one teaspoonful to a pint of water. If apparatus for eye-douching cannot be readily obtained, one of the following improvised procedures should be followed:—

(i) The casualty should bend over a bowl containing warm water or one of the mild fluids referred to above, and put the eyes, each in turn, well under water. They should be opened under water and the head moved from side to side.

(ii) The eyes should be opened in turn under a gentle stream of water from a tap, or from a rubber or other tube attached to a tap or hot water bottle, the head being moved slightly from side to side, and each eye opened and closed from time to time. Care should be taken to avoid contaminating an unaffected eye.

Any part of the skin contaminated with liquid blister gas should be dealt with at once. Where special anti-gas ointment is available, this should be instantly applied in accordance with the directions. In the majority of cases, however, this ointment will only be found at First Aid Posts and Cleansing

Stations and in the first aid equipment of Wardens and Casualty Service workers. An alternative method of treatment is therefore suggested employing solvents which are more usually in the possession of the ordinary citizen.

Liquid contamination may be removed from the skin by solvents such as petrol, spirit, or naphtha, and, since early treatment is vital, any of these should be used if it is more quickly available than ointment. To apply the solvent, a small piece of cotton wool or rag should be twisted into a pad and held between the finger and thumb, only the end being immersed in the solvent; as a further precaution against contaminating the fingers, a pair of oilskin or rubber gloves should be worn if they are available. It is important to avoid spreading the contamination by rubbing or by using an excess of solvent. The solvent only removes the blister gas by dissolving it; it does not destroy it. For this reason a succession of swabs should be used, and the contaminated swabs should be burnt or buried since they are dangerous.

Localised areas of contamination on the body should be treated as described, if the reagents required are readily available ; if not, the affected part should be thoroughly scrubbed with soap and water. In all cases where there has been contamination, it is advisable for the casualty to be washed completely with soap and water, in addition to the treatment described for the affected part.

In the case of exposure to vapour only, thorough washing with soap and warm water is sufficient.

It must be emphasised that the success of any method of preventive treatment depends upon the speed with which it is applied.

Lung Irritant Gas.

Whether symptoms are present or not, any person who has been exposed to a lung irritant gas must, from the outset, be spared any further exertion. He must be kept lying down and be protected from chill. He should be removed as a stretcher case.

Nose Irritant Gas.

The appearance of symptoms from exposure to nose irritant gases is slightly delayed, with the result that they may be felt a few minutes after the respirator has been adjusted. Any temptation to discard the respirator while still exposed to gas must be resisted. If vomiting occurs, the facepiece must not be removed ; affected persons should bend forward, turning the head to one side, and slightly raise the corner of the face-piece at the angle of the jaw while actual vomiting is taking place, dropping it into place between expulsive spasms. It is important that the facepiece should be allowed to fall back into place immediately, before the involuntary intake of breath which follows.

Summary

Where there are casualties requiring treatment and the Casualty Services are not immediately available, those on the spot, even if they do not know the precise treatment required, will very often be able, with elementary knowledge, to relieve the sufferings and possibly even to save the lives of the wounded.

The first consideration must always be to deal with any immediate danger to life. Examples of such dangers are excessive bleeding, interference with normal breathing (through pressure on the chest, obstruction of the air passages by debris or by electrocution), or nearness to moving machinery, tottering buildings, a spreading fire, or a poisoned atmosphere. In all such cases the source of danger must be removed from the casualty or the casualty moved away from the source of danger. After immediate danger to life, the second consideration is to try to avert or minimise injury, and the third to reduce pain and shock and make the casualty as comfortable as possible.

It may be convenient to sum up briefly some of the main guiding principles in elementary first aid :—

(i) Severe bleeding should be attended to at the earliest possible moment. This does not mean that every cut or wound should have prior attention. Discrimination should be used : the rule applies to profuse bleeding, the continuance of which would endanger life.

(ii) The casualty must be able to breathe normally : any cause of difficult breathing must be dealt with ; and artificial respiration, if needed, must be started promptly and maintained.

(iii) In cases of gross injury to a limb, whether or not a fracture is recognised, and in all cases of injury involving joints, the affected part should be supported and secured by simple methods before the casualty is moved, unless for any reason his life is in danger.

(iv) Any person who is, or has been, entrapped or buried under debris must be treated on the assumption that the severest crush injuries have been received. These might include fracture of the thigh, pelvis, or spine.

(v) A person who is wholly or partly unconscious, or one who is even suspected of suffering from internal injury, must not be given anything to eat or drink.

(vi) The indiscriminate use of alcohol in first aid can be dangerous ; it should not be given to persons suffering from any type of injury except on the direct order of a doctor.

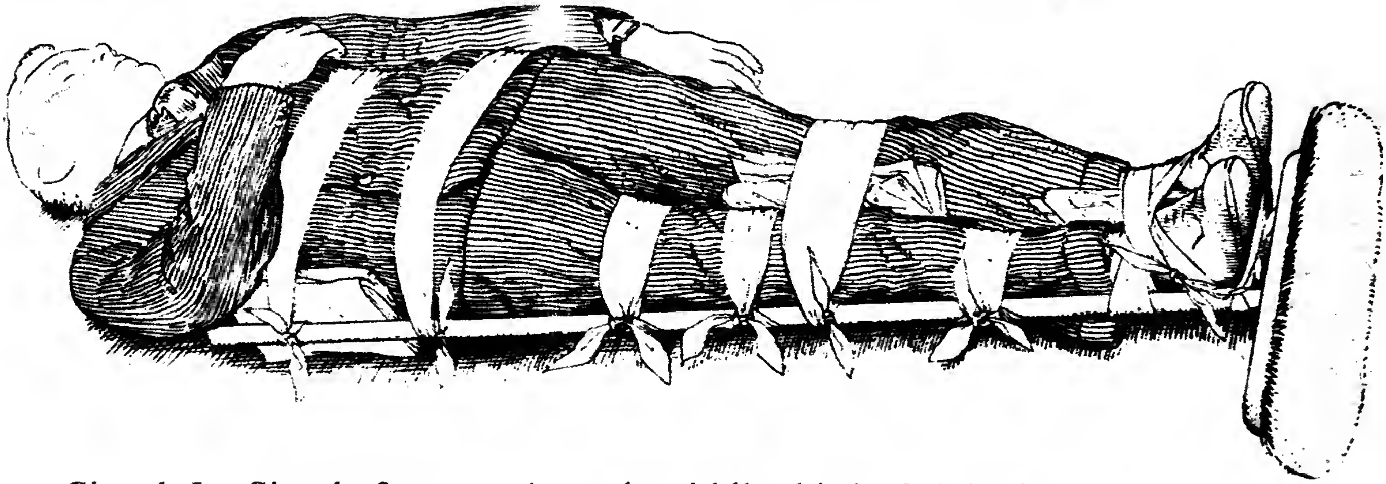
(vii) All injured persons will be suffering from Primary Shock ; Secondary Shock, coming on some time after injury, may be fatal. Secondary Shock can, to a large extent, be prevented by the simple measures mentioned in this chapter ; it may be brought on or made worse by rough handling and clumsy movement.

(viii) Chill should always be prevented; and the casualty should at all times be handled and moved with the greatest care and gentleness.

NOTES ON IMPROVISED SPLINTS

When the proper splints are not available, it will often be possible to improvise suitable substitutes in a number of different ways, which will at least serve temporarily while trained persons with proper equipment are on their way. A few examples showing how articles in common use may be made to serve as improvised splints are given in the illustrations which follow.

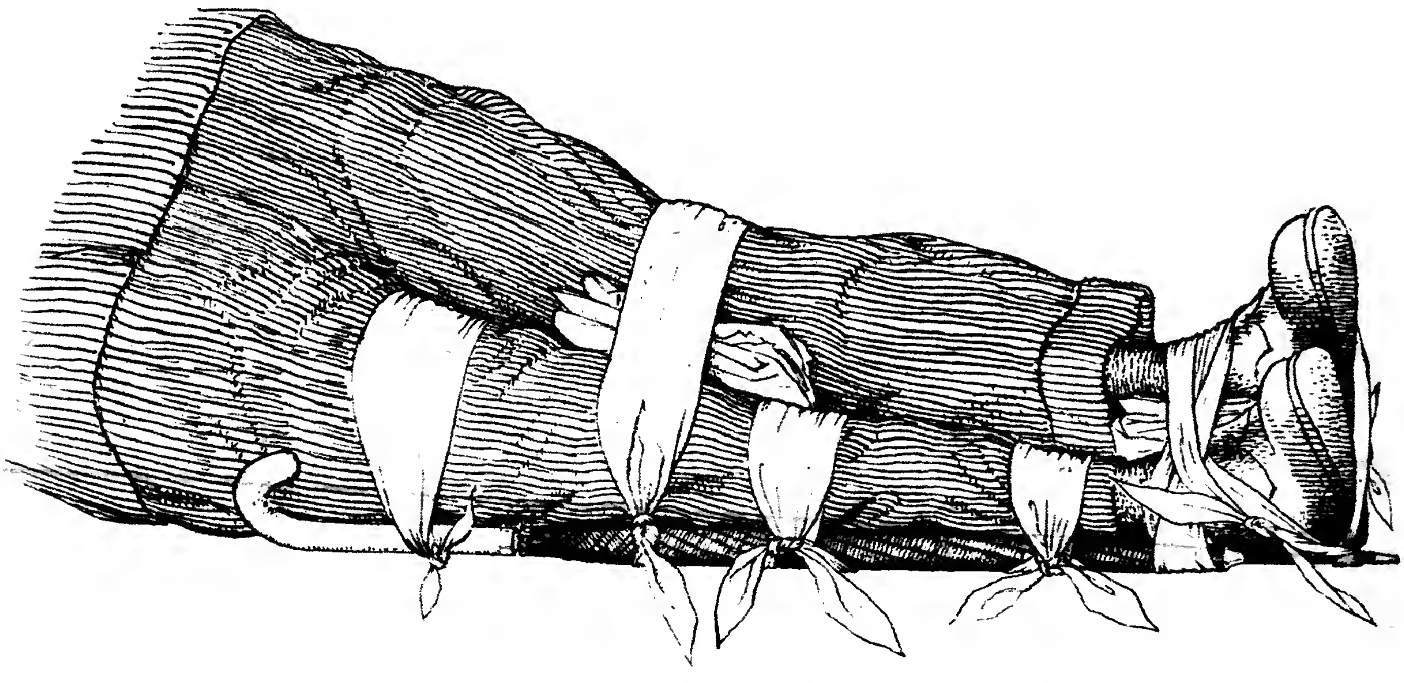
If sufficient bandages are not available to correspond with the illustration, it should be remembered that the important points are to bandage above and below the fracture, and to ensure that the limb is kept rigid.



Sketch I.—Simple fracture through middle third of right femur (thigh-bone).

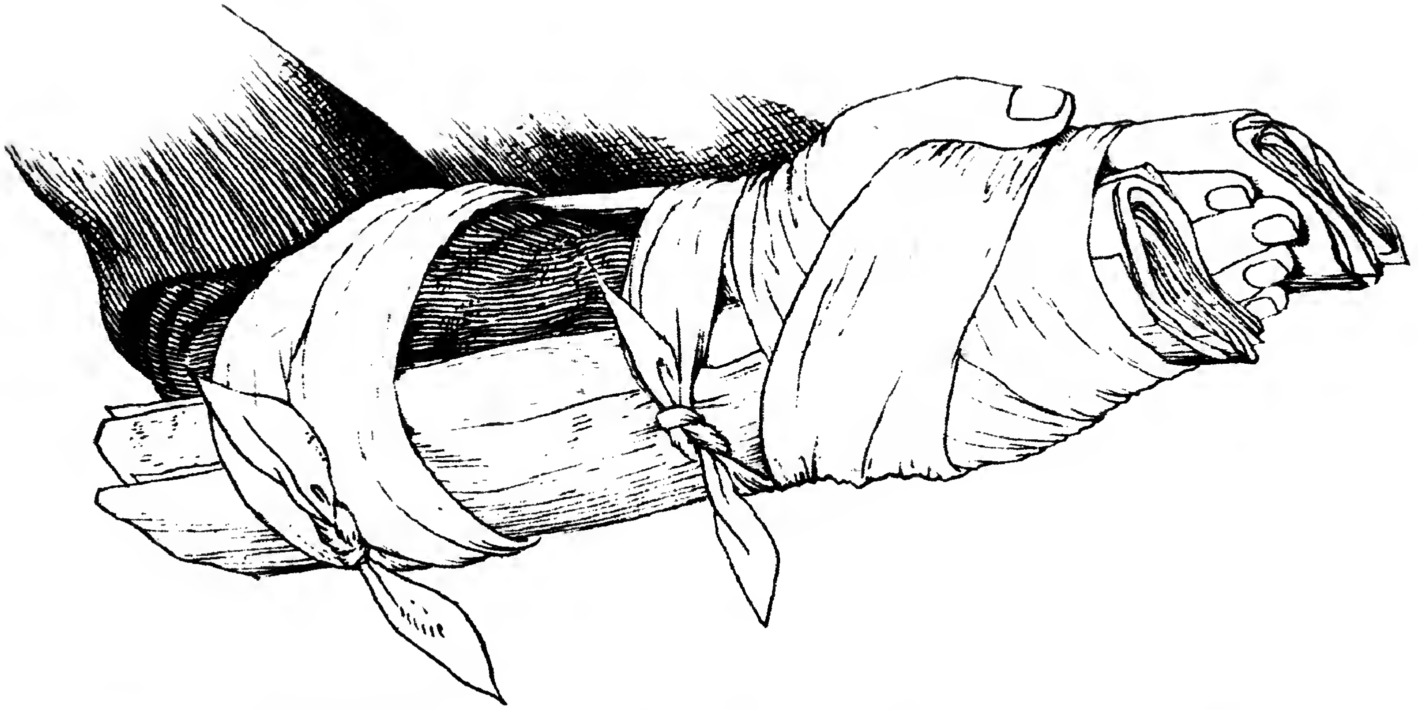
A broom used as a thigh splint by placing the handle along the injured limb, with the head of the broom at the feet. Loosely folded pieces of newspaper or other material may be used as padding, placed between the ankle and knee joints, and also at the hip.

Folded triangular bandages are shown in the illustration, but the improvised splint may be secured by any other material of sufficient length, such as, for example, neck-ties, belts, or scarves.



Sketch II.—Simple fracture through middle third of tibia (shin-bone).

The illustration shows an umbrella used as a splint. The ankles and knee joints are padded with loosely folded newspaper.



Sketch III. Simple fracture through one or both bones of the forearm.

The illustration shows the use of newspaper, folded to the approximate size of an arm splint, so as to be stiff enough to give rigid support.

APPENDIX

TABLE OF WAR GASES.

	1. **Properties.**	2. **Odour.**	3. **Effects Upon Human Body.**	4. **General Function of Group of Cases.**
Tear Gases.				
C.A.P. .. (*Non-persistent.*)	Solid; used in particulate cloud, almost invisible.	Aromatic, like floor polish.	Stinging of eyes, producing tears and spasms of eye-lids. Slight skin irritation.	Mainly harassing agents producing temporary results; effective in very low concentrations.
B.B.C. .. (*Very persistent.*)	Yellowish - brown crystalline solid when pure, but probably used in brown liquid mixture. Invisible in gaseous state.	Penetrating bitter sweet smell.	Stinging of eyes, producing tears and spasms of eye-lids. No skin irritation.	
Nose Irritant Gases.				
D.A.	Crystalline solid of arsenical nature; D.A. and D.C. are colourless; D.M. is bright yellow when pure and greenish-brown when impure. When heated all give off a particulate cloud, which is generally invisible except near the point of release.	Practically odourless.	Burning sensation in nose, mouth, throat, and chest slightly delayed, accompanied by sneezing and mental depression.	Harassing agents with temporary results; effects felt after slight delay.
D.M.				
D.C. .. .. (*Non-persistent.*)				
Lung Irritant Gases.				
Chlorine .. (*Non-persistent.*)	A greenish gas. It is a powerful oxydising agent, corroding metals swiftly and, more	Penetrating, like bleaching powder.	Coughing and watering of eyes: lung damage developing later.	

	slowly, rotting clothing, especially in the presence of moisture.			
Phosgene .. (*Non-persistent.*)	Almost invisible gas. Corrodes metal.	Like musty hay, producing suffocating sensation.	Ditto.	Lethal agents.
Chloro-picrin .. (*Semi-persistent.*)	Colourless liquid, perhaps yellowish in use.	Similar to Chlorine.	Ditto. Has pronounced lachrymatory properties and produces vomiting.	
Blister Gases.				
Mustard .. (*Persistent.*)	An oily liquid heavier than water, varying from dark brown to straw-yellow. May produce iridescent stain. Emits invisible gas. Liquid and gas have great powers of penetration.	Similar to garlic, onions, horse-radish or mustard. May be faint or pronounced.	Irritation producing inflammation in eyes and throat, possibly resulting in blindness and lung damage. Reddening and blistering of skin. Symptoms delayed, appearing from 2-8 hours or more after exposure.	Highly destructive to all living tissues.
Lewisite .. (*Persistent.*)	Colourless liquid when pure, but brown in crude state; heavier than water. Emits invisible gas. Liquid and gas have great powers of penetration. Contains arsenic.	Strong smell of geraniums.	Severe irritation to nose and damage to eyes and lungs, possibly with permanent effects. Reddening and blistering of skin. Effects noticed immediately.	
Other Gases.				
Arseniuretted hydrogen .. (*Non-persistent.*)	Invisible gas.	Practically odourless.	Headache, nausea, and vomiting, with pain in the back and stomach. Severe symptoms do not usually develop till an hour or two after exposure.	Affects the blood, the liver and the kidneys.

SELECTION OF OFFICIAL PUBLICATIONS

The series of Air Raid Precautions Handbooks and Memoranda has been produced by the Ministry of Home Security with the assistance of the Government Departments and other bodies concerned.

The Handbooks are designed to describe a scheme of precautions which it is hoped will prove effective in preventing avoidable injury and loss of life, or widespread dislocation of national activities. They aim at giving the best available information on methods of passive defence against air attack, and will be revised from time to time in the light of future developments.

The Memoranda deal with various aspects of the organisation to be provided by local authorities for public air raid precautions services.

HANDBOOKS.

No. 1. " **Personal Protection Against Gas** " (2*nd Edition*). **6d.** (8d.)

Gives rules of personal protection, and general knowledge of the nature and dangers of war gases.

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Provides information of both a general and technical nature required by nurses, first-aid parties, and the personnel of first-aid posts, to enable them to carry out their respective duties. Complementary to Handbook No. 1.

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Explains the general principles governing the methods of counteracting contamination arising from war gases. A text-book for the training of the members of decontamination services.

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THE SURFACE SHELTER

THERE can be no *absolute* safety anywhere from enemy attack. The courageous British people realises this. But months of bombing have proved that surface shelters stand up to nearby bomb explosions very well indeed. Look at these photos, typical of many from all parts of the country.

Time and time again well built surface shelters have kept their occupants safe even when surrounding buildings have been wrecked.

From a North-eastern town

STANDS UP TO IT WELL

From an East coast town

From a North-eastern town

City of Westminster.

AIR RAID SHELTERS AT NIGHT

See the BLUE LIGHT - it means SHELTER at NIGHT

Issued by Westminster City Council A.R.P. Office, Alhambra House, 31 Charing Cross Rd, W.C.2. 12th January 1940.

IN AN AIR RAID . . .

IF YOU ARE CAUGHT IN THE STREET

1 Don't stand and stare at the sky

2 Take cover at once

IN AN AIR RAID . . .

IF YOU ARE OUT OF DOORS

GET UNDER COVER AT ONCE

1 If in the open with no cover -lie down

2 If your home is within 5 minutes - go there

IN AN AIR RAID . . .

WHAT MOTORISTS MUST DO

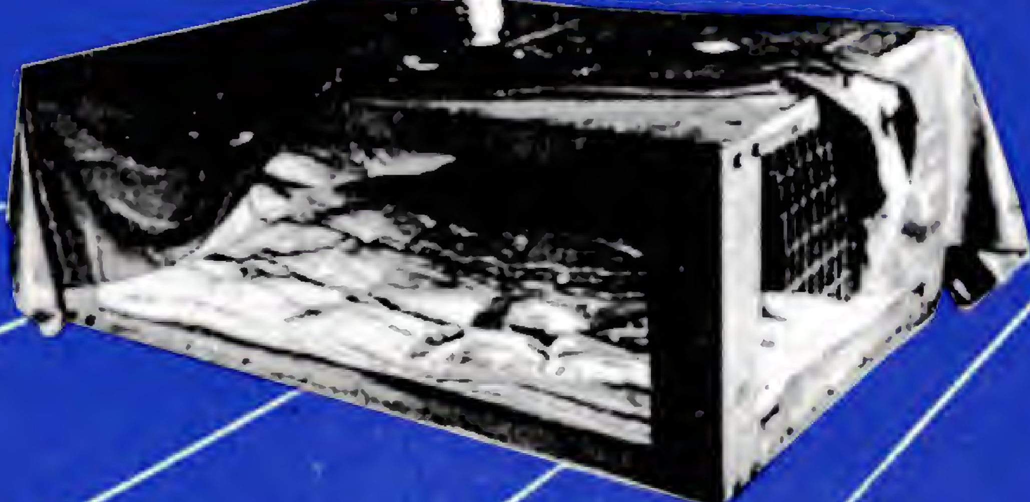
BY DAY

- Park your car off the main highway, close to the kerb.
- Obey promptly any instructions from police or air raid wardens.
- Go to the nearest shelter, or take cover.

AT NIGHT

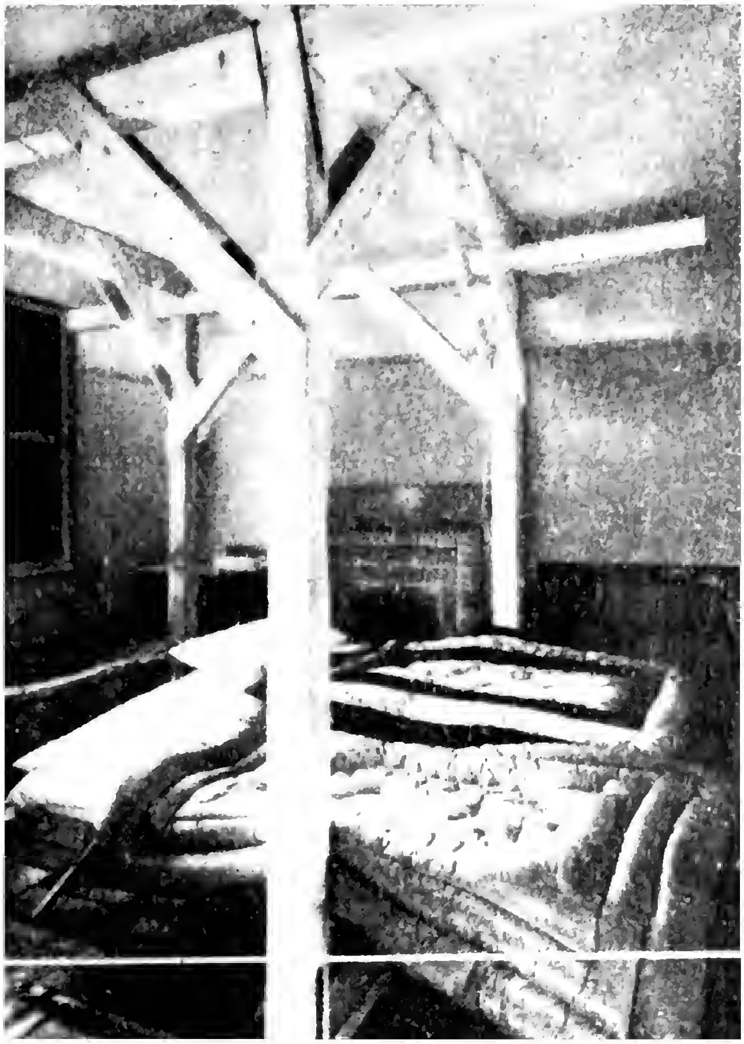
- Do the same as by day, but **SWITCH OFF YOUR HEADLAMP.** Leave rear and side lights on.

SHELTER at home

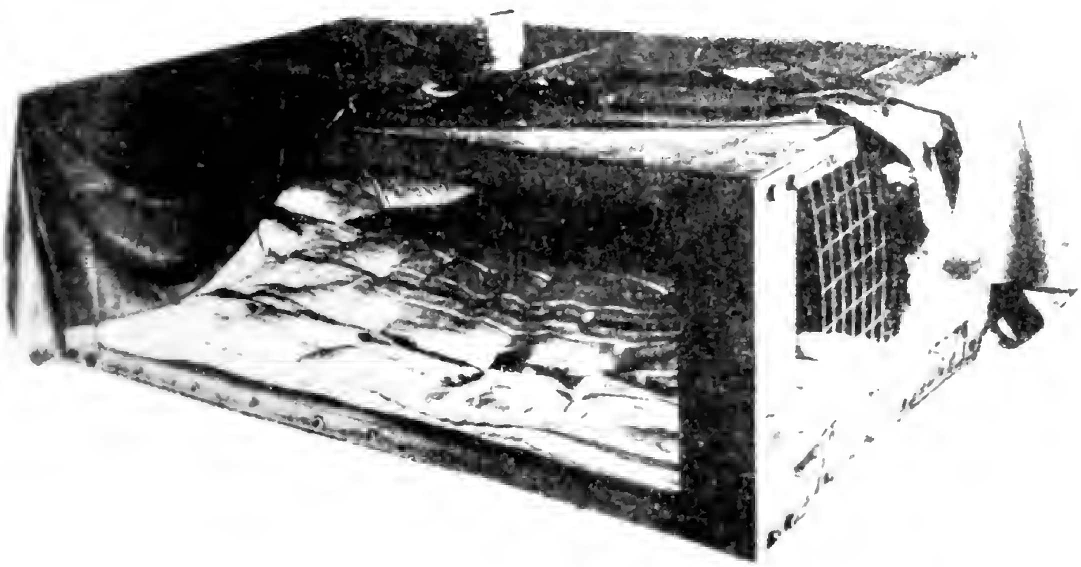


3d. ISSUED BY THE MINISTRY OF HOME SECURITY AND PUBLISHED BY H.M. STATIONERY OFFICE

June 1941



SHELTER at home



3d. ISSUED BY THE MINISTRY OF HOME SECURITY AND PUBLISHED BY H.M. STATIONERY OFFICE

Introduction

Not everyone wants to leave home for shelter. Some people can't. Lots of people just prefer to remain in their own house anyway. This inclination is a natural one. It is a sound instinct too, if some protection can be found against the collapse of walls and ceilings.

Shelter indoors allows you to sleep at night in reasonable security and in the warmth and comfort of your house. It also provides handy cover should there be a sudden raid in the day time.

A direct hit cannot be guarded against in any form of home shelter, but the risk of such a direct hit is very small compared with that of a bomb bursting near enough to damage the house or to demolish it. Protection can be obtained in a house even if a bomb demolishes most of it.

The walls, floors and roof of an ordinary house give quite a lot of protection against splinters and blast from a bomb. The idea of an indoor shelter is to make use of this protection and to add safeguards against the other effects of bombs.

The chief of these is the danger of the house falling down. People have often been rescued unhurt from the ruins of demolished houses because they had taken shelter under staircases, or tables, that had by chance been strong enough to protect them from the falling ruins of the house. The chief purpose of the indoor shelters described in this pamphlet is to protect the occupants against injury when the bedroom floor, the roof and other débris fall on them.

They do not provide such easy emergency escape as a garden shelter, but if you are trapped they protect you from the débris till the Rescue Party releases you. Very often, however, though the house has fallen you will be able to release yourself and walk out.

The indoor shelters with which this pamphlet deals are unsuitable for houses with more than two storeys above the shelter room. They are intended chiefly for use in ordinary two-storey houses, but have a margin of strength that will take the weight of an extra storey.

TYPES OF INDOOR SHELTER

Having chosen and prepared your refuge room, the next question is what sort of a shelter you will put in it. Three alternatives are dealt with in this pamphlet :

1. The Government steel indoor shelter

2. A commercially made shelter

3. A home-made timber-framed structure which the technical services of the Ministry of Home Security have designed.

Government shelters

The Government are distributing free to eligible householders an indoor shelter made of steel. It will also be on sale to householders not eligible for free shelter. These shelters, whether free or on sale, will be distributed first in the more exposed areas. Public announcement is made in each area when the local council is ready to receive applications for shelters.

The model at present being issued consists of a strong frame, a flat top, a spring mattress forming a floor, and sides of open mesh.

The top of the shelter is sheet steel, and the shelter can be used as a table. The mattress is attached to the frame, so that should the shelter be moved when struck by débris, the occupants will be carried with it. The fact that the shelter can move a little helps it to resist the weights falling on it. The four steel mesh sides are so made that they resist blows from débris, such as loose bricks from a demolished wall, but they can all easily be opened from inside. This " table " shelter has been thoroughly tested.

The shelter will be supplied in sections and you must put it together yourself. This does not require any special skill or strength. A leaflet of simple instructions, and the necessary tools, will be supplied with the shelter.

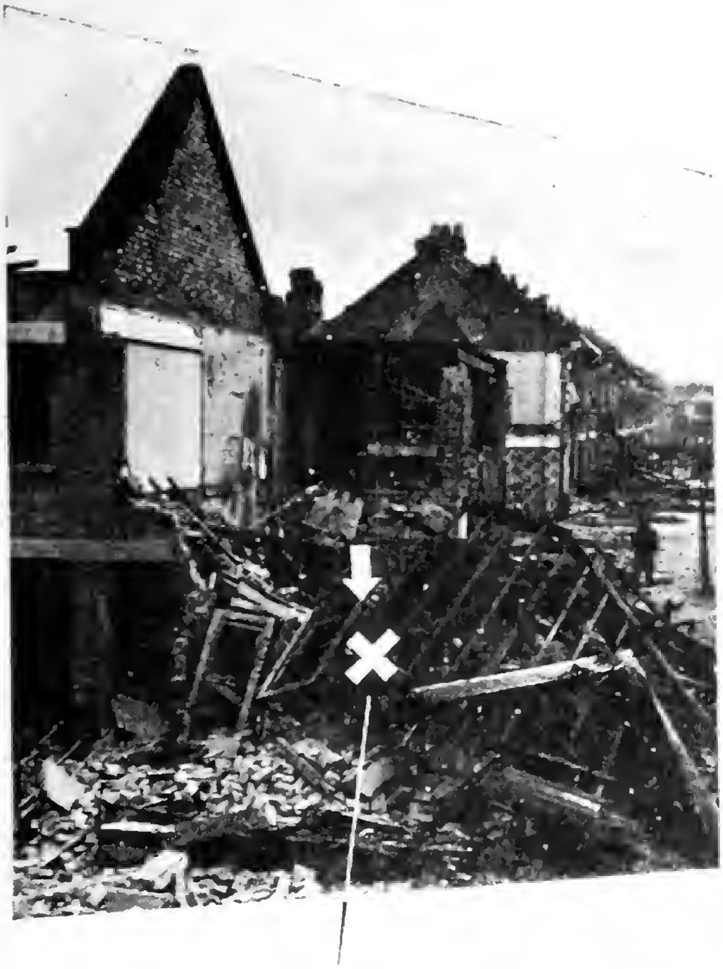
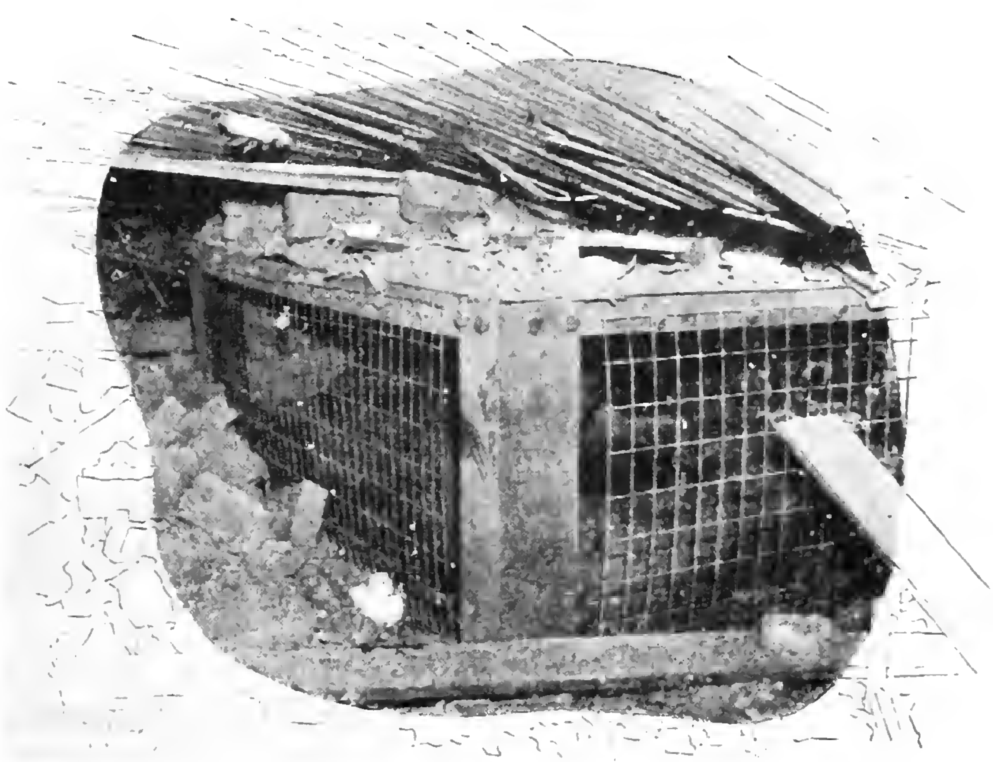


ILLUSTRATION NO. 8.

The house in the upper photograph had a Government steel table shelter in a downstairs room and was blown up to reproduce the effect of a heavy bomb falling near. The whole house collapsed, burying the shelter under débris. In the lower photo the shelter can be seen still intact. It would have been possible for anyone in the shelter to get out unaided.



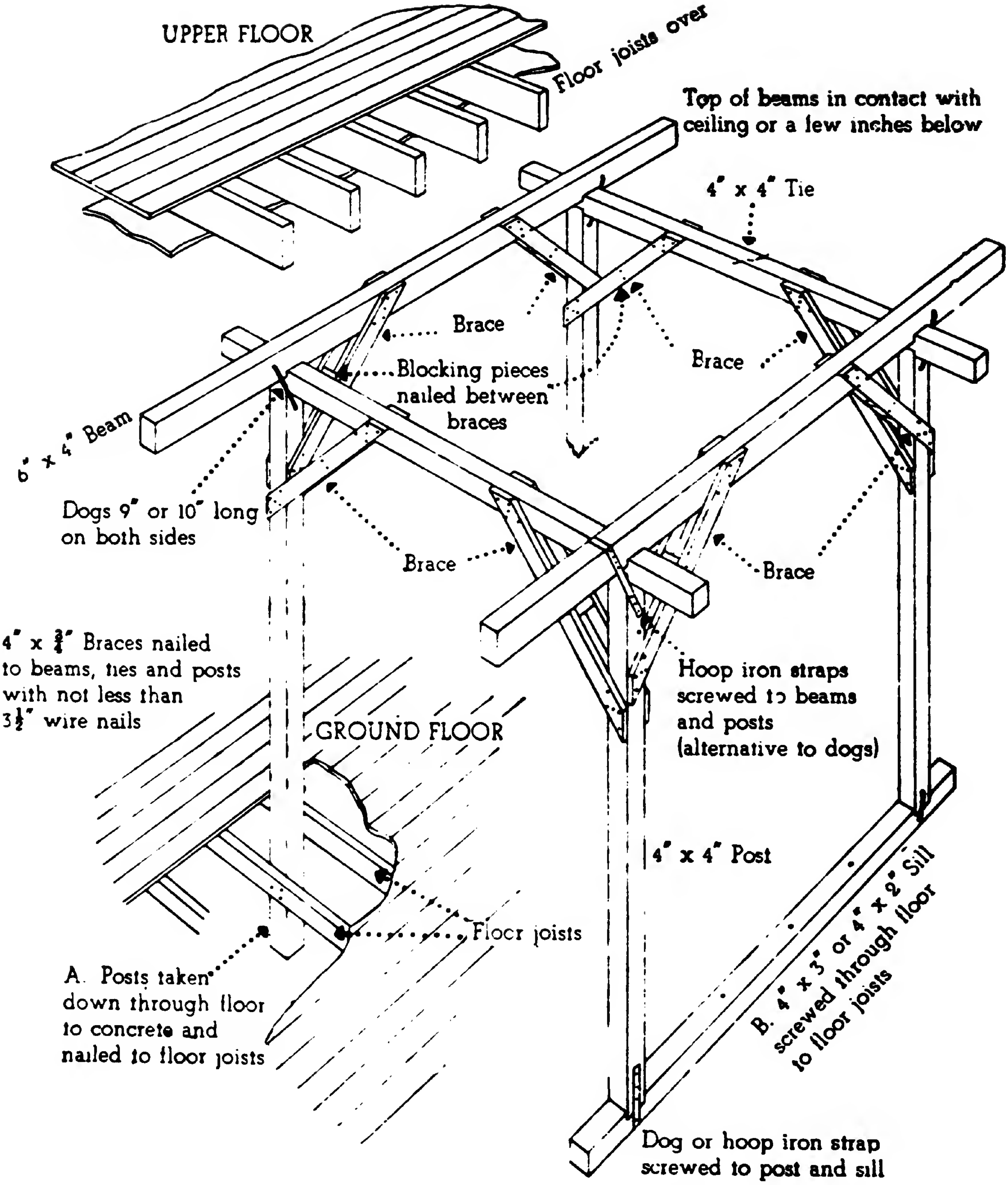


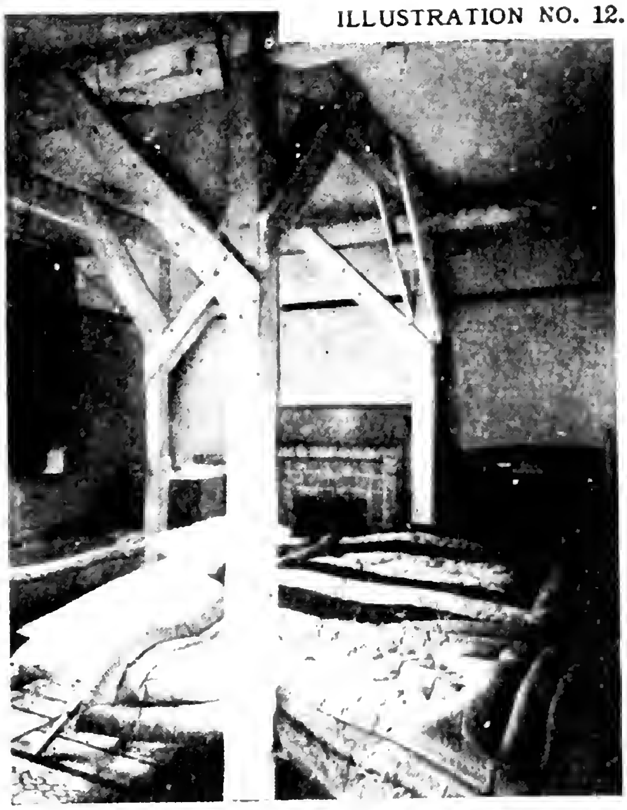
ILLUSTRATION NO. 11. Independent timber framework for a refuge room. If the posts are more than 6 ft. 6 in. apart, 8 in. × 4 in. beams are desirable.

A home-made shelter

You will have noticed earlier in this booklet the statement that people have often been rescued from demolished houses because they had taken shelter under an ordinary table. This was because the table had by chance been strong enough to bear the weight of the falling bedroom floor. A timber framework can be built inside a refuge room to do the same thing, but with certainty. ILLUSTRATION NO. 11 shows a completed framework in squared

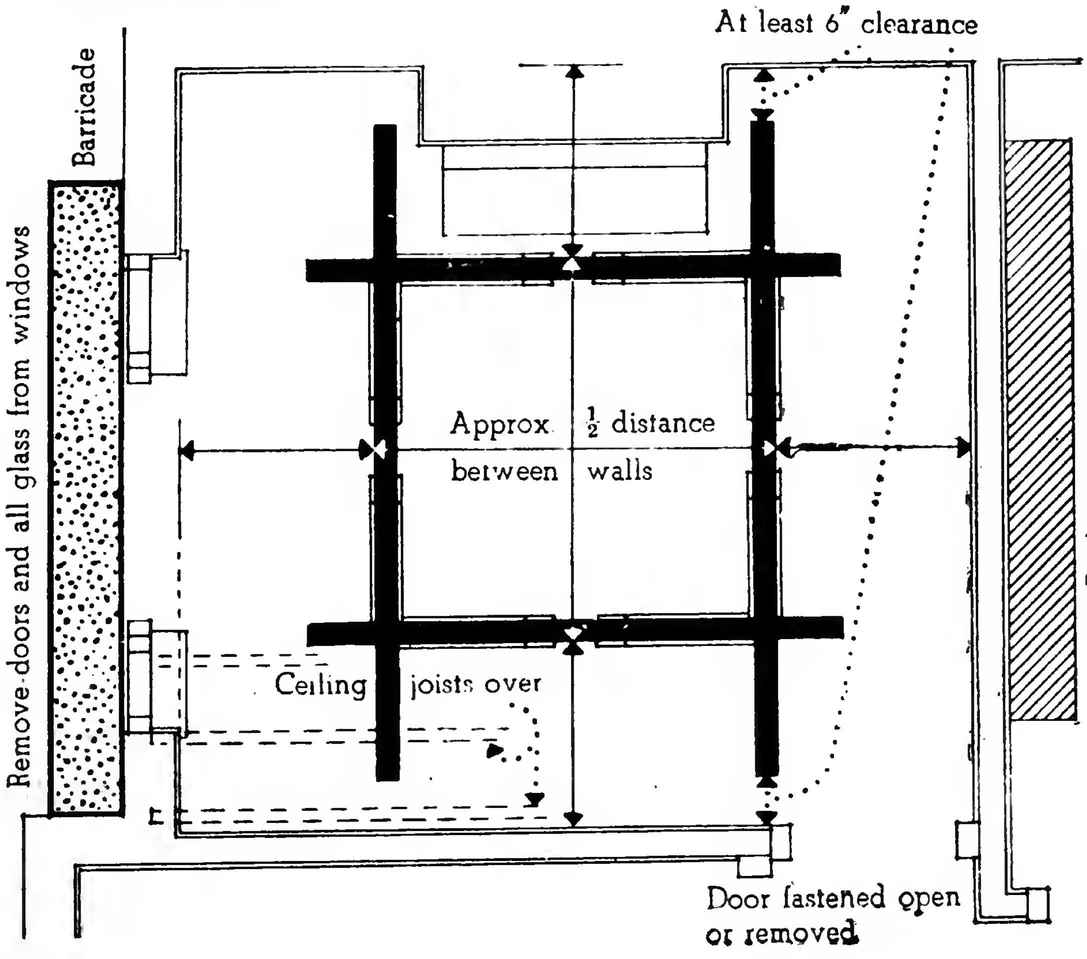
timber. ILLUSTRATIONS NOS 12 and 13 show how it goes into a refuge room. As, however, squared timber is more difficult to get, the use of round poles, as shown in ILLUSTRATION NO. 14, is specially recommended. (Poles of larch and Scotch fir can be obtained fairly easily in many districts.) ILLUSTRATION NO. 15 shows how this is put together. A refuge room with a framework of this kind to hold up the floor, and a properly barricaded window, gives a high degree of safety. It is best to sleep in the middle of the room under the framework, as there is less chance of your being hurt if parts of the wall fall inwards, though walls more often subside or fall outwards.

ILLUSTRATION NO. 12.



The framework is quite different in principle from propping up a floor. When a floor falls it gives a sideways push which is likely to knock props over. The framework is specially designed to be self-supporting and to withstand

ILLUSTRATION NO. 13.
Plan of a typical refuge room with an independent timber framework.
The room is the same as the dining room in Illustration No. 1.



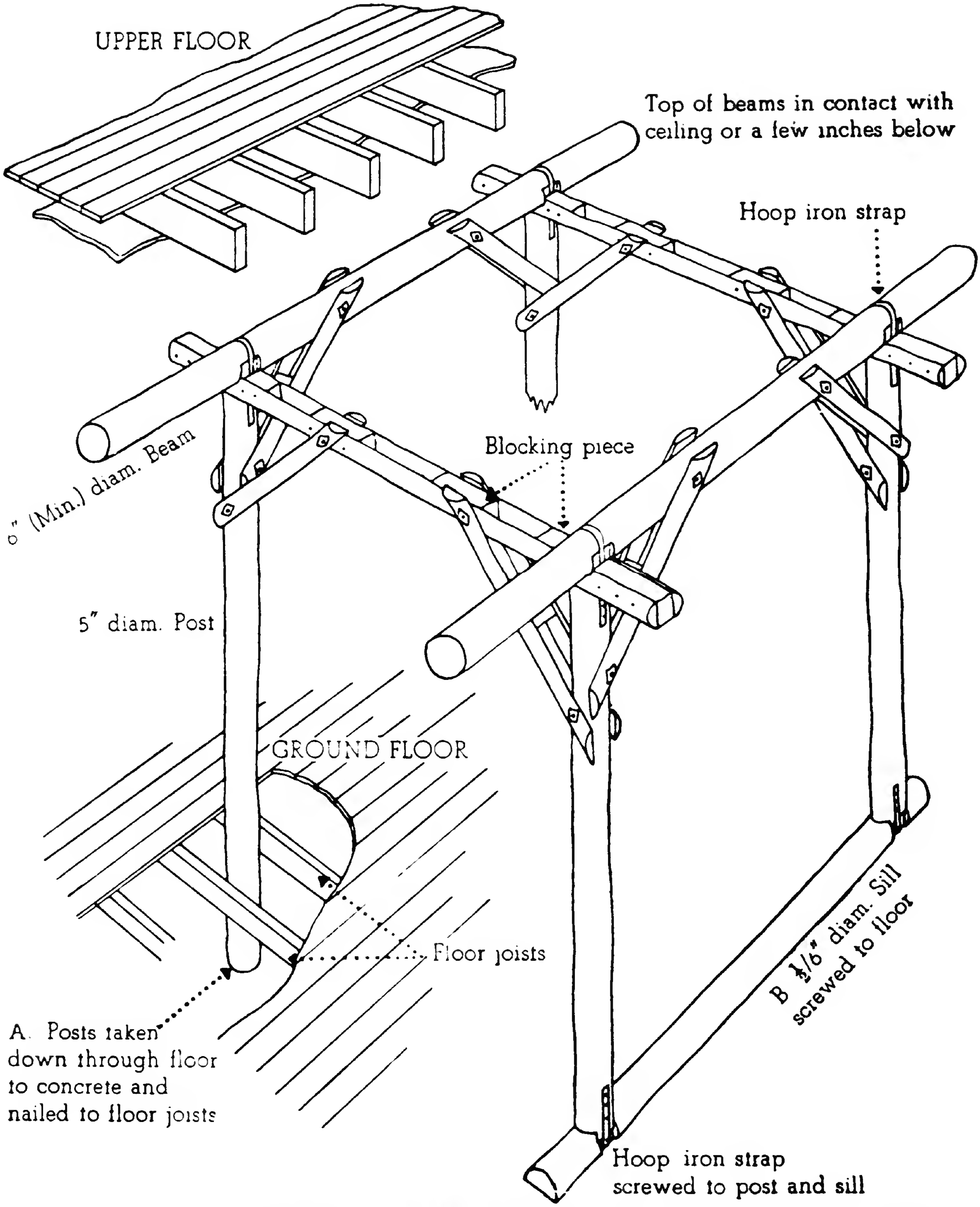


ILLUSTRATION NO. 14. Alternative construction of timber framework to that shown in Illustration No. 11. Round poles are used instead of squared timber.

this. You can make the framework in several ways, so long as the general principles given here are followed. The dimensions should be such that the posts stand at a distance from the walls approximately one quarter of the width or length of the room; thus, if the room is 10 ft. wide by 12 ft. long, the posts will be about 2 ft. 6 in. from the side walls and 3 ft. from the end walls. The dimensions can be varied a little if necessary, but do not overdo it.

The posts may either be passed through small openings in the floor boards

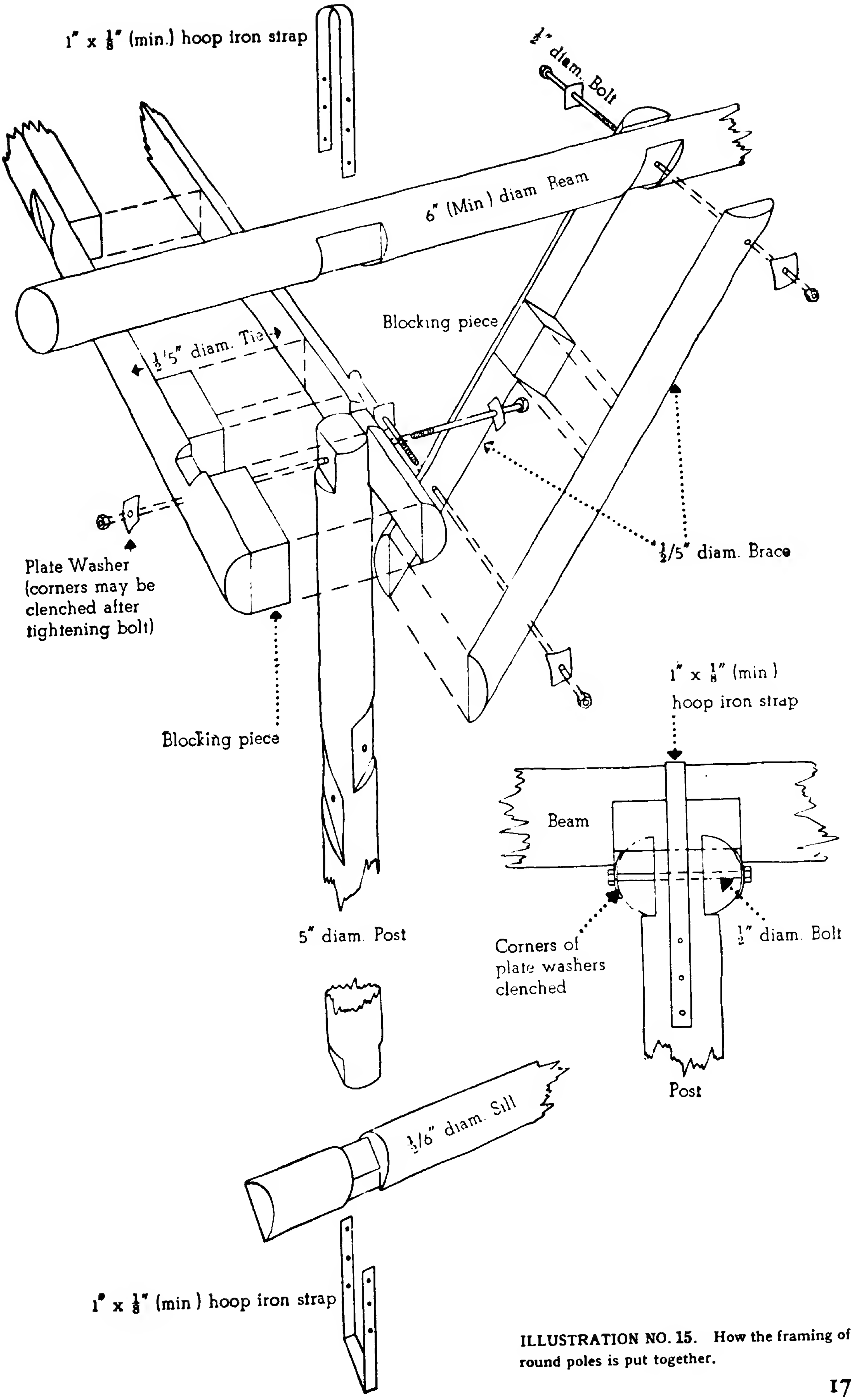


ILLUSTRATION NO. 15. How the framing of round poles is put together.

to bear on the solid concrete below, or fixed to a beam or heavy plank screwed to the floor, as shown in ILLUSTRATION NO. 11. If the space under the floor is deeper than 18 in. the posts must extend down to the concrete. The two highest beams of the framework must be placed at right angles to the ceiling joists ; their ends should not be nearer to the walls than about 6 in., so as to be safe from the chance of being struck heavily by the wall should it collapse. You can tell which way the ceiling joists run by observing the line of nails in the floor boards in the room above. The beams of the framework need not touch the ceiling, but they should not be more than 2 or 3 in. below.

Falls of ceiling plaster seldom cause serious injuries, but plaster can be brought down by blast, even if the walls and floors are not damaged. It is a simple matter to catch the pieces of plaster by fixing a layer of wire netting, fishing net, or something similar, over the top of the framework, and fixing it to the walls all round the room. Dust sheets, paper, etc., spread over the netting will prevent most of the smaller pieces coming through the netting. If you cannot get a strong netting, a canopy can be arranged by means of a dust sheet or bed sheet, supported on cords stretched tight from wall to wall over the framework.

The construction of the framework is a straightforward job, involving not much more than a saw, hammer and nails. The amateur carpenter or handyman should be able to do it with someone to help him put up the framework in the room. As none of the pieces of wood is as long as the dimension of the room along which it is to be placed, there should be no difficulty in getting everything into the room. Any local builder or carpenter would be able to do the job in a day or two, using the illustrations as working drawings.

Material

As rough timbers in 5 in. to 6 in. diameters are not much in demand, persons requiring material for A.R.P. purposes should not, as a rule, experience difficulty in obtaining the necessary permit from the Ministry of Supply, Timber Control Department, for the purchase of small quantities. The same applies to " limbs " in home-grown hardwoods, which are also available in many areas. The Timber Control Orders permit a purchaser to buy up to 20*s*. worth of timber per calendar month without a licence. Amounts in excess of this require a licence, which can be obtained from the Timber Control Area Officer.

ILLUSTRATION NO. 16. The house on the right had a timber framework in the front sitting room. The framework has slightly twisted but held up the debris. The house on the left has no framework and has collapsed. This was an experiment similar to that in Illustration No. 8.

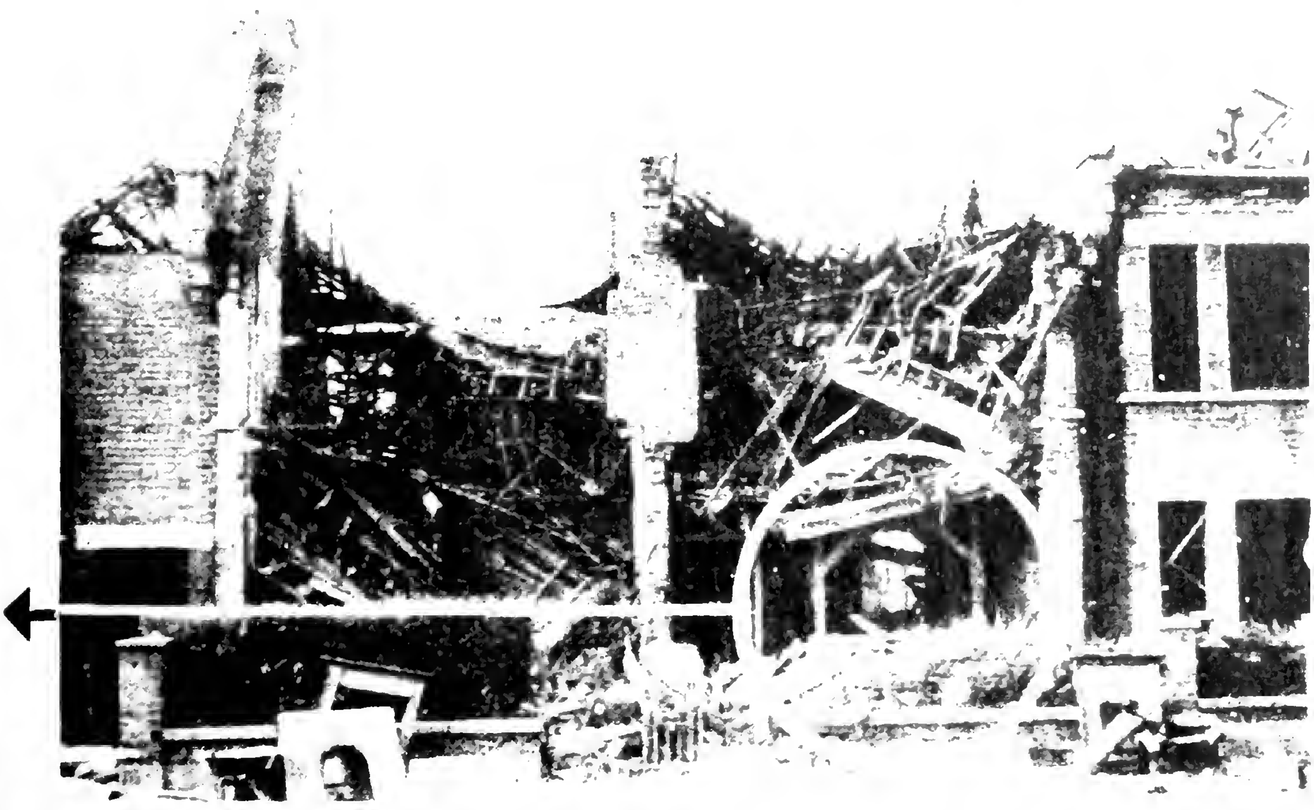
As there are only about 12 cu. ft. of timber in a ceiling support as shown in ILLUSTRATION NO. 11, suitable for a room measuring up to 12 ft. by 12 ft. by 9 ft. high, it should not be a difficult matter for anyone to obtain the small quantity of green timber required, especially if a tree, or part of one, is purchased before it is felled, so as to obtain as much timber as possible within the 20s. limit. Alternatively, it is possible to obtain from some Local Authorities timber of suitable sizes salvaged from bombed houses.

Obtained in the ordinary way, the timber for a single framework costs about £4; to this must be added the cost of transporting it to your house. The same amount of salvaged timber should cost from £1 to £3, but will probably need cutting to the right sizes; transport costs will be extra to this.

How to obtain skilled advice

For a fee of half a guinea, a consultant appointed by one of the professional institutions of architects, engineers or surveyors will inspect your house and give you a written report stating the best room for a refuge in your house and describing ways within your means by which the protection it gives can be improved. If you want the services of such a consultant ask your Local Authority to show you a list of consultants from which you can choose. If your local council has no such list, you can apply for information to the

Secretary, Central Board of Advisory Panel of Professional Consultants,
1–7 Great George Street,
Westminster,
London, S.W.1.



ALWAYS HAVE YOUR GAS MASK WITH YOU — DAY AND NIGHT LEARN TO PUT IT ON QUICKLY

PRACTISE PUTTING ON YOUR GAS MASK

1. Hold your breath.
   (To breathe in gas may be fatal.)

2. Hold mask in front of face, thumbs inside straps.

3. Thrust chin well forward into mask. Pull straps as far over head as they will go.

4. Run finger round face-piece taking care head-straps are not twisted.

MAKE SURE IT FITS

See that the rubber fits snugly at sides of jaw and under chin. The head-straps should be adjusted to hold the mask firmly. To test for fit, hold a piece of paper to end of mask and breathe in. The paper should stick.

Arrows indicate points needing particular attention.

AN ANALYSIS OF 259 OF THE RECENT FLYING-BOMB CASUALTIES

BY

R. C. BELL, M.B., M.R.C.S.

Resident Surgical Officer to an E.M.S. Hospital

In all we dealt with 222 out-patients and 259 in-patients, with 18 deaths. Our story began in June, 1944, when the first large incident occurred near by. Twenty-six casualties were admitted and 12 required theatre treatment. This proportion remained fairly constant throughout the series. Altogether we had 83 theatre cases out of 259 admissions, and had to send 35 cases on untreated, most of whom required the theatre. In this first incident no fewer than 16 of the casualties were due to flying glass. It was noticeable how the proportion of glass injuries dropped as the importance of taking adequate cover was realized, while the percentage of crush injuries increased from people being trapped by falling masonry.

A. Flying Glass

This was the most frequent cause of injury, totalling over 100 casualties in all. Many included severe damage to the eyes. It is noticeable that most of the injuries were above the nipple line, chiefly of the face and neck: a large proportion were received when looking out of windows—a modern version of curiosity killing the cat. We had five cases of perforating wounds of both eyes and ten perforating wounds of one eye. The globe was usually completely destroyed. Many of these injuries were avoidable, and therein lay their great sadness.

The penetrating power of flying glass is, in the main, low. It is unusual for it to pierce the deep fascia: usually it lies just under the skin in the fat, but when present in hundreds of pieces it presents a problem which has not yet acquired a satisfactory solution ; nor has the condition made its way into the textbooks of war surgery.

TABLE I.—*Glass*

Description	No.	Remarks	Deaths
Lacerations of face, scalp, and neck ..	77	19 T	—
Perforating wounds of eye	15	5 cases bilateral 2 T	—
Cut hands	9		
Severe multiple lacerations	6	1 T	1
Other injuries	5	—	—

HOME OFFICE

AIR RAID PRECAUTIONS

DIRECTIONS FOR THE ERECTION AND SINKING OF THE GALVANISED CORRUGATED STEEL SHELTER

February 1939

(ANDERSON SHELTER)

A.R.P. (O) 10

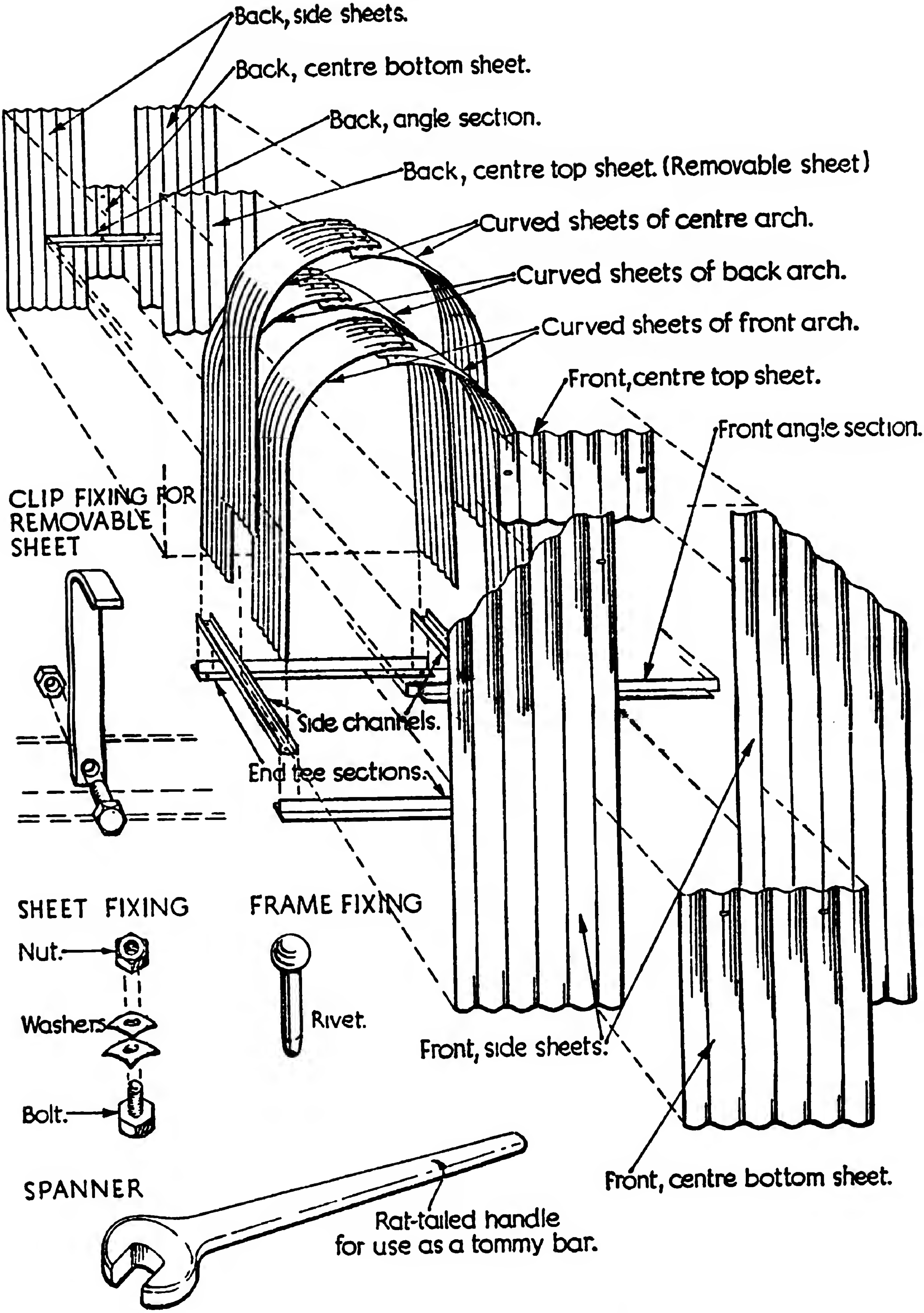


FIG. 3.—THE INDIVIDUAL PARTS.

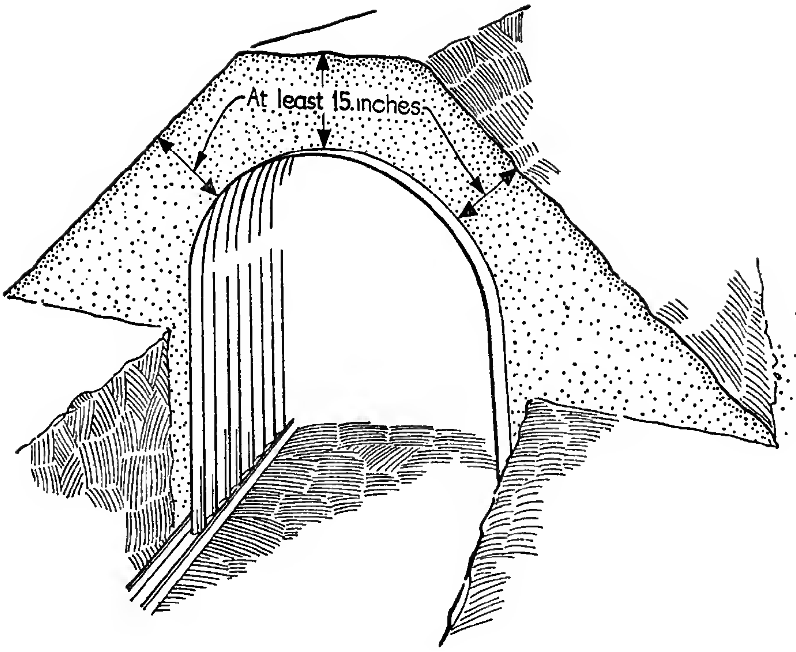


FIG. 4.—STAGE 12. COVERING THE SHELTER WITH EARTH.

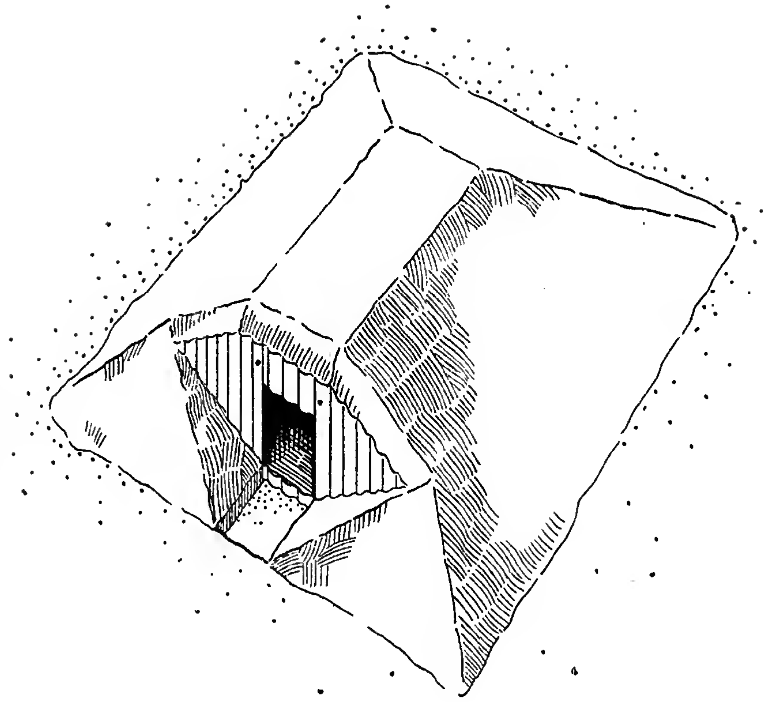
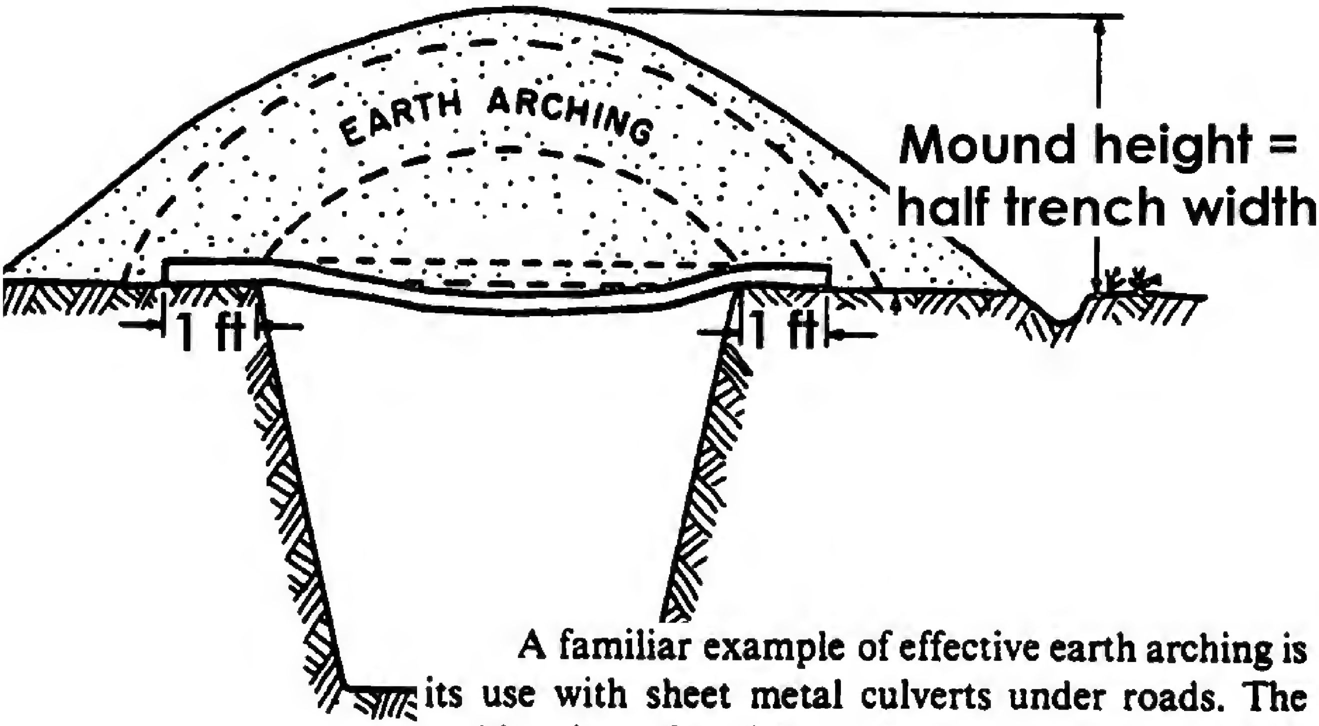


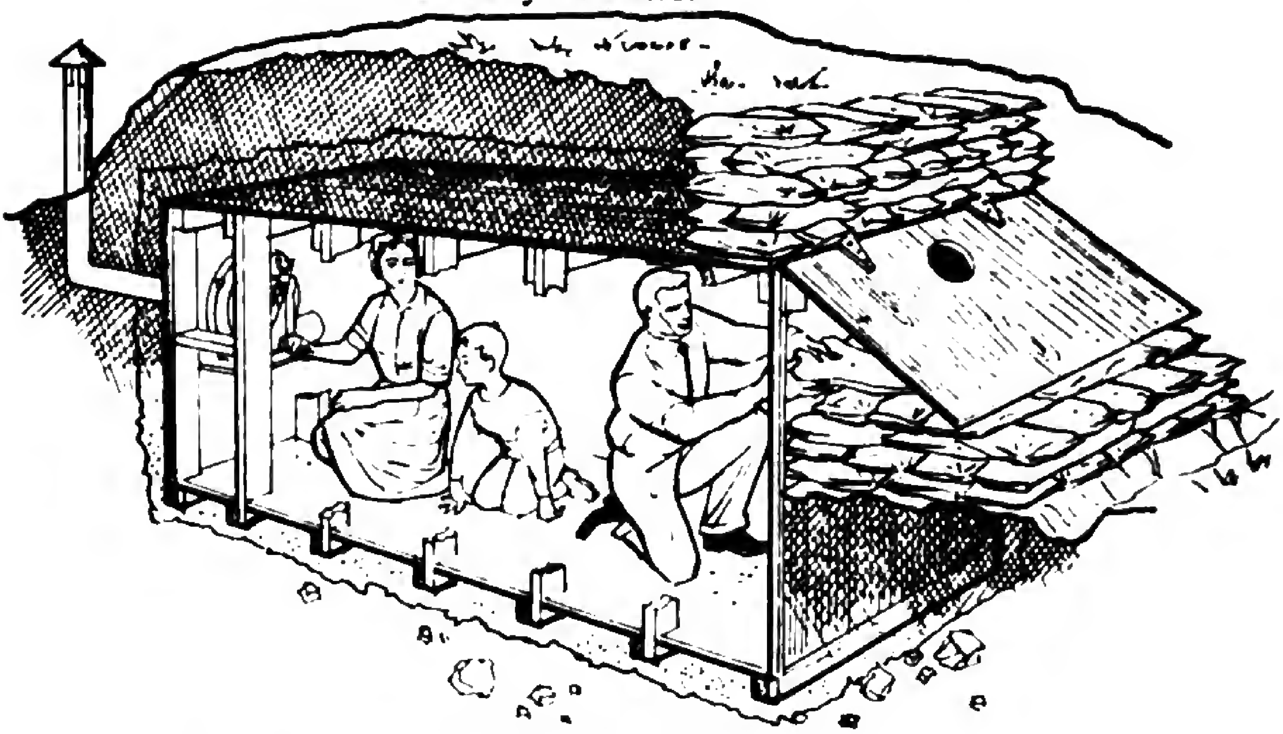
FIG. 4.—STAGE 13. THE SHELTER COMPLETE WITH EARTH COVER.

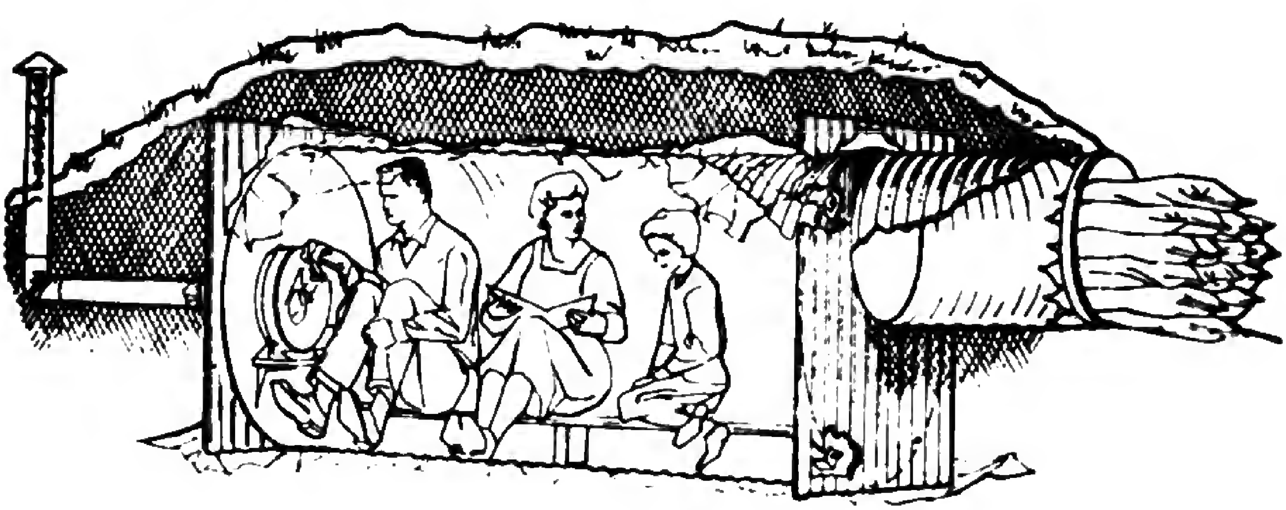
Anderson shelter survives hit: Norwich 27 April 1942

EARTH ARCHING USED TO STRENGTHEN SHELTERS



A familiar example of effective earth arching is its use with sheet metal culverts under roads. The arching in a few feet of earth over a thin-walled culvert prevents it from being crushed by the weight of heavy vehicles.





15 Sept 1940: Anderson shelter occupants survived air raid, Ransome Way, Liverpool

Anderson shelter occupants survive air raid destruction at Purfleet

17 June 1944: Anderson shelter absorbs blast from V1 at Elsenham Rd, East End, London

Family survive without injury in wrecked Anderson shelter (note earth blown off) during London Blitz in 1940. Damage to the shelter absorbed the blast energy.

28 Jan 1945: Priory Road, East Ham

27 April 1944: Anderson shelter occupants survive at Forest Drive, East End, London

10 July 1944: Anderson shelter occupants survive air raid at Harcourt Avenue, East End, London

17 July 1944: Anderson shelter occupants survive at Tennyson Ave, Plashet Grove

AFFORDING STRIKING PROOF OF THE EFFICACY OF ANDERSON SHELTERS: ALMOST MIRACULOUS ESCAPES IN MIDLAND AND SOUTH OF ENGLAND HOMES.

AN ANDERSON SHELTER, CORRECTLY COVERED WITH EARTH (FROM WHICH CABBAGES SPROUT), UNHARMED DESPITE SURROUNDING BOMB DAMAGE. *Wide World.*

DAMAGED HOUSES, WITH AN UNTOUCHED ANDERSON SHELTER IN THE FOREGROUND, WHOSE OCCUPANTS FOUND COMPLETE SAFETY. *(Planet.)*

INTACT AMONG THE DÉBRIS CAUSED BY GERMAN BOMBS: AN ANDERSON SHELTER IN A S.-W. LONDON SUBURB. *(Planet.)*

TWO ANDERSON SHELTERS IN THE SAME DISTRICT AS THAT SHOWN IN THE PHOTOGRAPH ON THE LEFT, ALSO INTACT. *(Planet.)*

A LARGE BOMB-CRATER BEHIND A ROW OF DAMAGED HOUSES AFTER THE CROYDON RAID: THE SHELTERS WERE UNAFFECTED. *(Keystone.)*

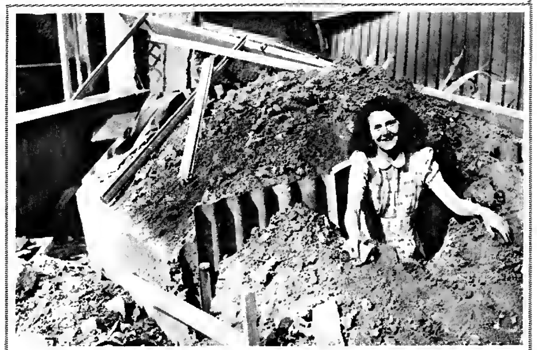
THE violent and very expensive raids by the *Luftwaffe* in the week ending August 17 provided a most reassuring demonstration of the efficacy of the Anderson shelter, when it has been properly covered with earth and the entrance adequately screened. Both at Croydon and in the Midlands its value was proved. When a bomb dropped in the middle of a triangle formed of three Anderson shelters in a Midlands town the occupants of all escaped unhurt. Seven people taking cover in a home-made shelter, however, were killed. Seven persons sheltering in an Anderson shelter in another Midlands area were unharmed by a bomb which exploded immediately outside it. When sixteen Nazi bombers were caught at Tilbury (Essex) between the A.-A. barrage and "Spitfires," they scattered and fled to sea with a vicious pursuit encouraging them. Six of their bombs fell on a housing estate. Four exploded harmlessly on grass verges, and two blew out the sides of a council house, but the occupants were in their Anderson shelter, less than ten yards away, and were unhurt. One man in South London, with his wife and two children, who had been evacuated from Folkestone, said that they were in an Anderson shelter during the raid on August 18 when five bombs fell within a distance of 100 yards. "Our little shelter trembled," he said, "but we suffered no shock and no damage, though our windows were broken." On the other hand, people in an Anderson shelter in the South-Western suburbs were injured by bomb splinters penetrating the back of the shelter, which was not completely covered with earth.

A CRATER, 25 FT. DEEP, OUTSIDE A DAMAGED HOUSE IN CROYDON. ALL THE OCCUPANTS OF THE SHELTERS ESCAPED INJURY. *(Topical.)*

HARDLY THE "COWERING" LONDONERS OF DR. GOEBBELS' IMAGINATION: A CHEERFUL NORTHFLEET FAMILY SITTING BY THEIR SHELTER AFTER A RAID. *(Fox.)*

AN UNDAUNTED MIDLAND FAMILY, DUG OUT AFTER A BOMB HAD BURST BEHIND THEIR SHELTER—WHICH SAVED THEM. *(A.P.)*

MR. AND MRS. SHERMAN, OF CROYDON, WITH THEIR BABY, BY THEIR SHELTER, ON EACH SIDE OF WHICH BOMBS BURST. *(G.P.U.)*



GIVING THE LIE TO GOEBBELS: MRS. E. CULLEN SMILINGLY LEAVING THE EMERGENCY EXIT—A BOMB HAVING BLOCKED THE SHELTER ENTRANCE. *(Planet.)*

AFFORDING STRIKING PROOF OF THE EFFICACY OF ANDERSON SHELTERS:

ALMOST MIRACULOUS ESCAPES IN MIDLAND AND SOUTH OF ENGLAND HOMES.

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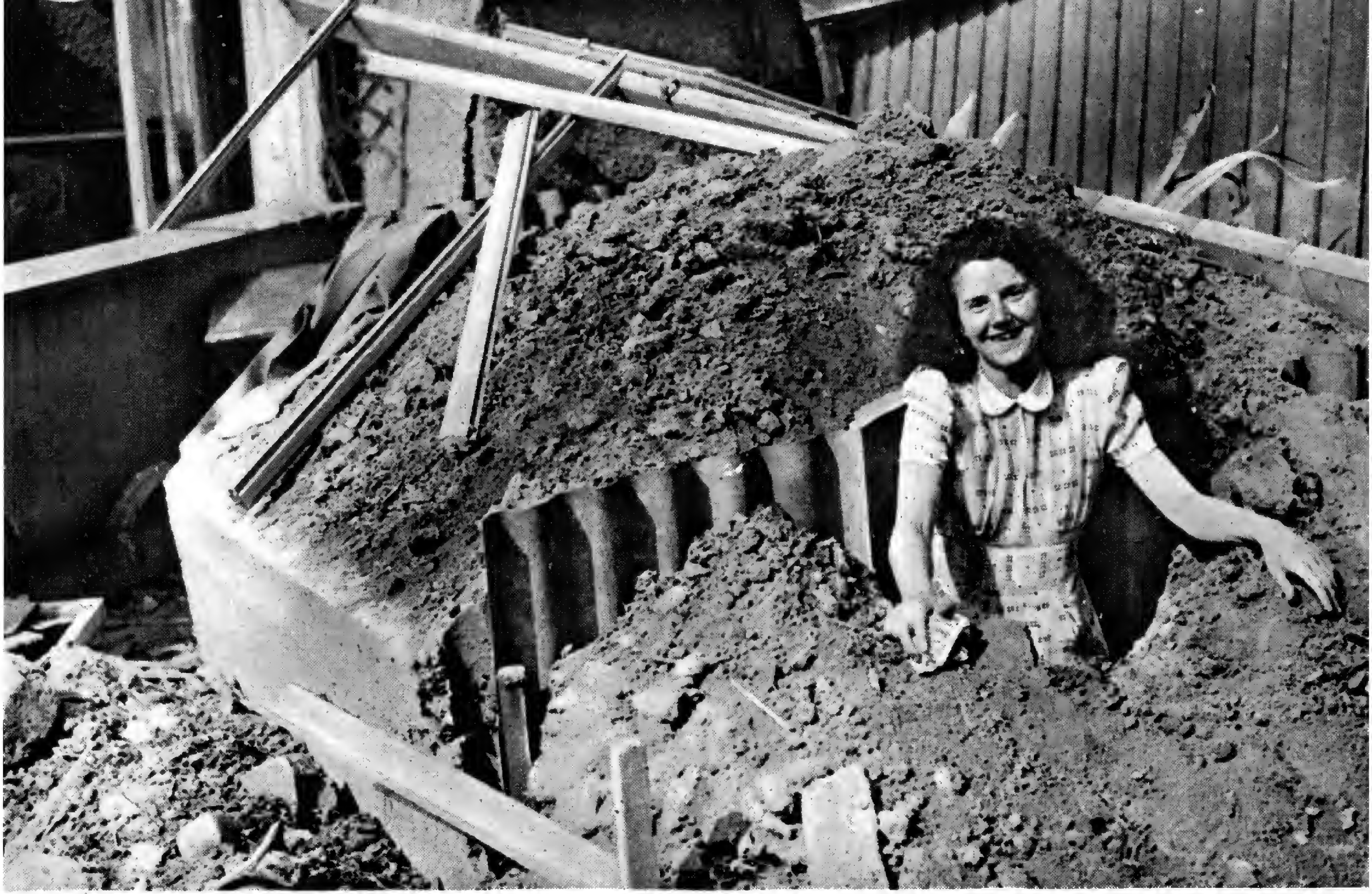


GIVING THE LIE TO GOEBBELS: MRS. E. CULLEN SMILINGLY LEAVING THE EMERGENCY EXIT—A BOMB HAVING BLOCKED THE SHELTER ENTRANCE. (*Planet.*)

Anderson shelter survives, Croydon, October 1940

29 July 1944: St Johns Rd, London, Mr and Mrs Dermott and Sgt Harrington

Proof that the Anderson garden shelter could withstand a house collapsing on it can be seen in this picture. Mr. and Mrs. Clague bless their insistence on 'going to ground' when their homes and those of their neighbours were reduced to rubble.

18 June 1941

Anderson shelter survives at Latham Street, Poplar, London, 28 July 1941:

Anderson shelter beside crater (August 1940)

And They Came Out of It Alive . . .

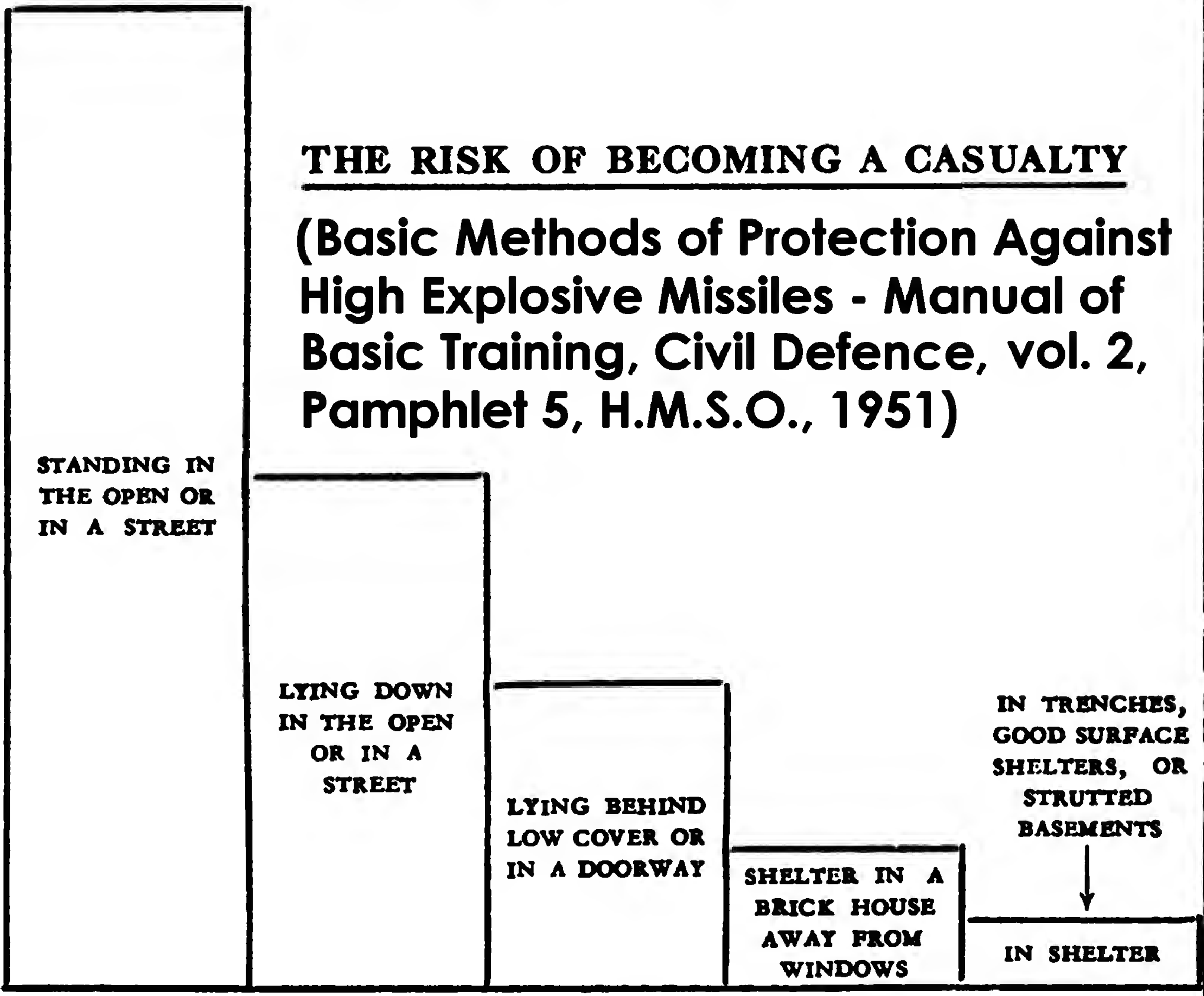
The edge of this bomb crater, 30ft. deep, in a household garden near London, is only 4ft. from the Anderson shelter. But the two people in the shelter during London's six-hour raid—Mrs. Clark and Miss Clark—were unhurt. You see Miss Clark in the picture examining the damage to the structure.

Daily Mirror
28 Aug 1940

It cannot be too strongly emphasised that it is most important, from the point of view of reducing casualties as a whole, for everyone in an area under attack to make use of any shelter that is available. Recent research has shown that there would be less fatal casualties if everyone were in relatively poor shelter than if half the population were in shelter twice as good and the other half remained in the open.

THE RISK OF BECOMING A CASUALTY

(Basic Methods of Protection Against High Explosive Missiles - Manual of Basic Training, Civil Defence, vol. 2, Pamphlet 5, H.M.S.O., 1951)



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HOME OFFICE

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OFFICE OF THE CHIEF SCIENTIFIC ADVISER

A COMPARISON BETWEEN THE NUMBER OF PEOPLE KILLED PER TONNE OF BOMBS DURING WORLD WAR I AND WORLD WAR II

BOMB SIZES

=> ≈ 175 kg

For World War II the average bomb weight was between 150 - 200 kg. (R.C. 268, Table 6), whereas for World War I the majority of bombs were 12 or 50 kg.

TABLE 5

Relative safeties in World War II deduced from population and casualty distribution

	In the open	Under cover	In shelter
Population exposure	5%	60%	35%
Location people killed	19%	62%	19%
Relative safety	72%	20%	10%
RELATIVE DANGER!			

(1) A house about 3½ times as safe as in the open.
(2) A shelter about twice as safe as a house.

Table 6 also shows the location of killed which is implied by each of the possible population exposures. The only evidence available on this point is that, for the day raid on June 13th, 1916, in which the total number killed was 59, 69.5% of the people killed in the City were in the open.

Reprinted as amended in accordance with the Decision of the Assistant Comptroller, acting for the Comptroller-General, dated the nineteenth day of July, 1944, under Section 11, of the Patents and Designs Acts, 1907 to 1942.

PATENT SPECIFICATION

Application Date: Sept. 20, 1940. No. 14411/40.

544,710

Complete Specification Left: April 4, 1941.

Complete Specification Accepted: April 24, 1942.

PROVISIONAL SPECIFICATION

A Protective Shield for Beds and the like

I, ALFRED ETHELBERT MOSS, a British Subject, of 20, William IVth Street, Charing Cross, London, W.C.2, do hereby declare the nature of this invention to be as follows:—

This invention has for its object to provide a protective shield for beds and the like, to protect the occupant from injury by projectiles or falling splinters or the like, and also from the collapse or partial collapse of the building, or, in general terms, to ensure a certain measure of protection against injury during air-raids.

According to this invention, a protective shield for a bed or the like comprises standards supporting a roof-like structure over the bed.

The roof may be of composite form comprising a plate, grid or like strong element to support a weight collapsing upon it, and a yielding material such, for example, as a mattress lying on top of the plate or other member, to resist penetration by projectiles, falling splinters or the like.

If desired, additional protection may be provided by means of side screens supported from the top of the shield and constituted by a wire mesh, grid or like flexible material.

The details of mechanical construction of the shield may be varied according to specific requirements and according to the materials which are available. In one embodiment, the shield may be provided with a base constituted by a rectangular frame built up of angle-irons to surround the bed, with an upright at each corner. These also may be of angle-iron and they support at their upper end a rectangular frame similar to that at the base, and the top frame may be provided with cross-bracing if so desired. A steel plate can be laid on the top frame, or secured thereto and this plate, for convenience in handling, may be divided into sections. Instead of a rigid plate a grid or wire mesh or the like may be substituted for it. The object of this plate or equivalent device is to withstand the heavy loads which may arise on collapse of the building, or from a ceiling falling.

On top of the strong element of the roof there is laid a cushioning material, such as a mattress or the like, which will effectively stop flying fragments or splinters.

Side screens may be provided, supported from the various members of the upper frame, to afford protection against fragments which are travelling more or less horizontally; these screens may be rigid plates but, preferably, are of a flexible nature, such, for example, as a stout wire mesh sheet or some equivalent material.

The structure is preferably made of sufficient size closely to enclose the bed, and extends to a height of, say, 4 feet above the bed so that a patient can sit upright in the bed or be attended to whilst in bed.

In a modified construction, instead of using a base frame, each of the standards at the four corners of the bed may be independently carried on a base-plate which, preferably, will be screwed or otherwise secured to the floor. Instead of using angle-irons, steel tubes may be used to construct the frame, or if steel is not available, wooden poles of a suitable size may be used for the uprights, and these would be conveniently mounted in sockets in the base-plate. The top frame would similarly be provided with sockets to engage the upper ends of the poles.

Instead of securing the structure to the floor, the standards could be clamped to the bed-frame itself, or to the bed-posts, or if desired the bed-posts could be extended upwards to a height of 4-feet or so above the bed, and the top frame secured on them to carry the protective shields.

The shield according to this invention may, of course, be used for protecting any bed, but it is of particular value in hospitals and like institutions where it may not be possible to remove the patients in times of emergency, as a very considerable measure of protection can be afforded to them.

Dated this 20th day of September, 1940.

BOULT, WADE & TENNANT,
Chartered Patent Agents,
111 & 112, Hatton Garden,
London, E.C.1.

[Price 1/-]

COMPLETE SPECIFICATION

A Protective Shield for Beds and the like

I, ALFRED ETHELBERT MOSS, a British Subject, of 20, William IVth Street, Charing Cross, London, W.C.2, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention has for its object to provide a protective shield for beds and the like, the protect the occupant from injury by projectiles or falling splinters or the like, and also from the collapse or partial collapse of the building, or, in general terms, to ensure a certain measure of protection against injury during air-raids. It is not concerned with covers such as are provided on children's cots to prevent the occupant climbing out, or with enclosures such as mosquito-nets.

According to the invention, a protective shield for a bed or the like comprises uprights supporting a roof-like strength member, such as a plate or grid to support a weight collapsing upon it and side-screens to provide lateral protection against flying fragments and the like. There may also be provided a yielding material on the strength-member aforesaid to resist penetration by flying fragments.

The details of mechanical construction of the shield may be varied according to specific requirements and according to the materials which are available.

The accompanying drawings, Figures 1 and 2, illustrate various constructions according to the present invention.

In Figure 1, the shield is of a form to provide protection for an ordinary bed. It comprises a base 10 constituted by a rectangular frame built up of angle-irons and is of such a size as to surround the bed, with uprights 11 at the four corners. These also may be of angle-iron, and they support at their upper end the rectangular frame 12 which may be similar to that constituting the base, and this top frame may be provided with cross-bracing, indicated at 13, if so desired. A steel plate 14 is laid on the top frame, or secured thereto, and whilst it may be made in one piece it may, alternatively, for convenience in handling, be divided into sections.

Instead of a rigid plate, a grid or wire mesh or equivalent device may be substituted for it, the object of this plate or equivalent device being to withstand the loads which may arise on the collapse of the building or from the ceiling falling on it. On top of the plate 12 or equivalent strong element of the roof, there may be provided a cushioning material 15, such as a mattress or the like, which will effectively stop flying fragments or splinters, it being well-known that such fragments are more effectively stopped by a yielding material than by a rigid material.

In order to provide protection against fragments which are travelling more or less horizontally, side screens 16 are provided, extending between the upper frame 12 and the base 10; these screens could be rigid plates but are preferably of a flexible nature, such as a stout wire mesh screen or an equivalent structure, and one or more of them may be readily detachable to provide easy access to the bed.

This structure is made of sufficient size to enclose the bed and in this particular form the uprights 11 are of sufficient length to extend to a height of, say, four feet above the bed so that a patient can sit upright in the bed or be attended to whilst in the bed.

Figure 2 shows a modified construction of a similar shelter. In this case each of the uprights 17 is independently carried on a base-plate 18 which is screwed or otherwise secured to the floor, and they carry a top frame which is illustrated as being provided with an open screen, but may be constructed as described with reference to Figure 1.

Figure 2 also shows that instead of using angle-irons for the structure, steel tubes may be used for the various members, these tubes being connected together by suitable sockets 19.

Any of the forms of the invention may be constructed with wood or any other suitable material which is available for the purpose.

The bed may be supported from the uprights of the shield or alternatively the uprights of the shield may be secured to the posts of the bed in any convenient manner.

In the constructions illustrated the top shield is shown as flat, but if desired it may be sloped, for example from one end to the other, or it may be of an inverted V formation, so that a proportion at least of the debris falling on it will fall off, and thereby reduce the load which it has to support.

The shield according to this invention may, of course, be used for protecting any bed, but it is of particular value in hospitals and like institutions where it may not be possible to remove the patients in times of emergency, as a very considerable measure of protection can be afforded to them.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A protective shield for a bed or the like, comprising uprights supporting a roof-like strength-member, such as a plate or grid to support a weight collapsing upon it and side-screens to provide lateral protection against flying fragments and the like.

2. A shield according to claim 1, comprising also a yielding material on the strength-member to resist penetration by projectiles, flying splinters and the like.

3. A shield according to claim 1 or claim 2, comprising a base-frame provided with uprights and a top frame supported on said uprights with a strength-member carried by said top frame.

4. A shield according to claim 1, constructed as a unit separate from, but adapted to enclose, the bed.

5. A shield according to claim 1, wherein the bed is supported on the uprights of the shield.

6. A shield according to claim 1, whereof the uprights are independently secured to the floor.

7. A shield according to claim 1, wherein the uprights are secured to the posts of the bed.

8. A shield according to any of the preceding claims, wherein the roof is sloped, for the purpose set forth.

9. The improved shield for a bed or the like, substantially as described with reference to the accompanying drawings.

Dated this 4th day of April, 1941.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden,
London, E.C.1.
Chartered Patent Agents.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1944.

Fig. 1.

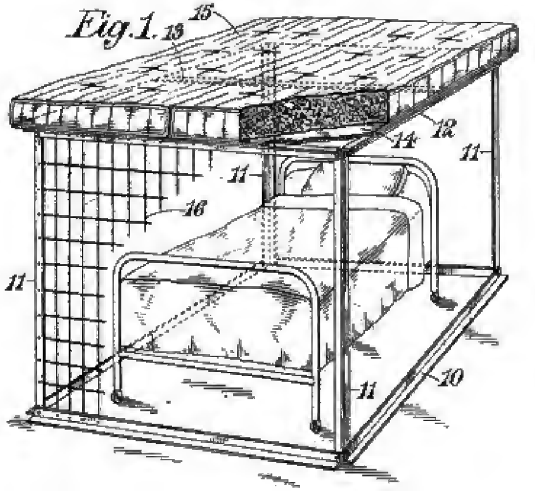
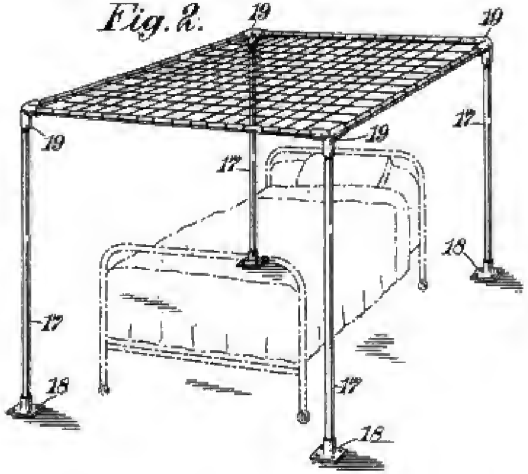


Fig. 2.



November 1940 design by C. A. Joy, M. Inst. Me. & C. E.,
Bexley Borough Engineer (UK National Archives: HO 205/257)

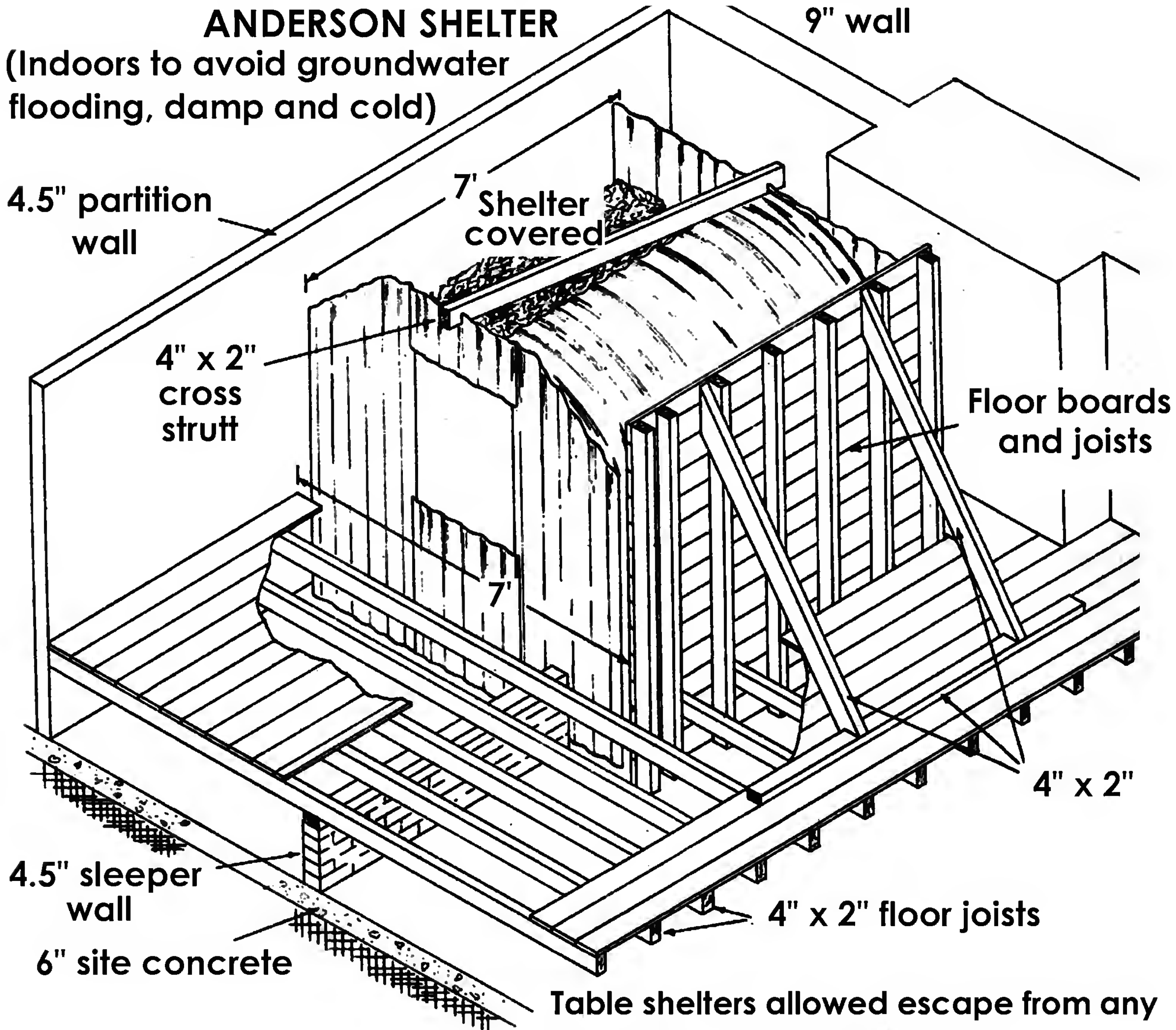
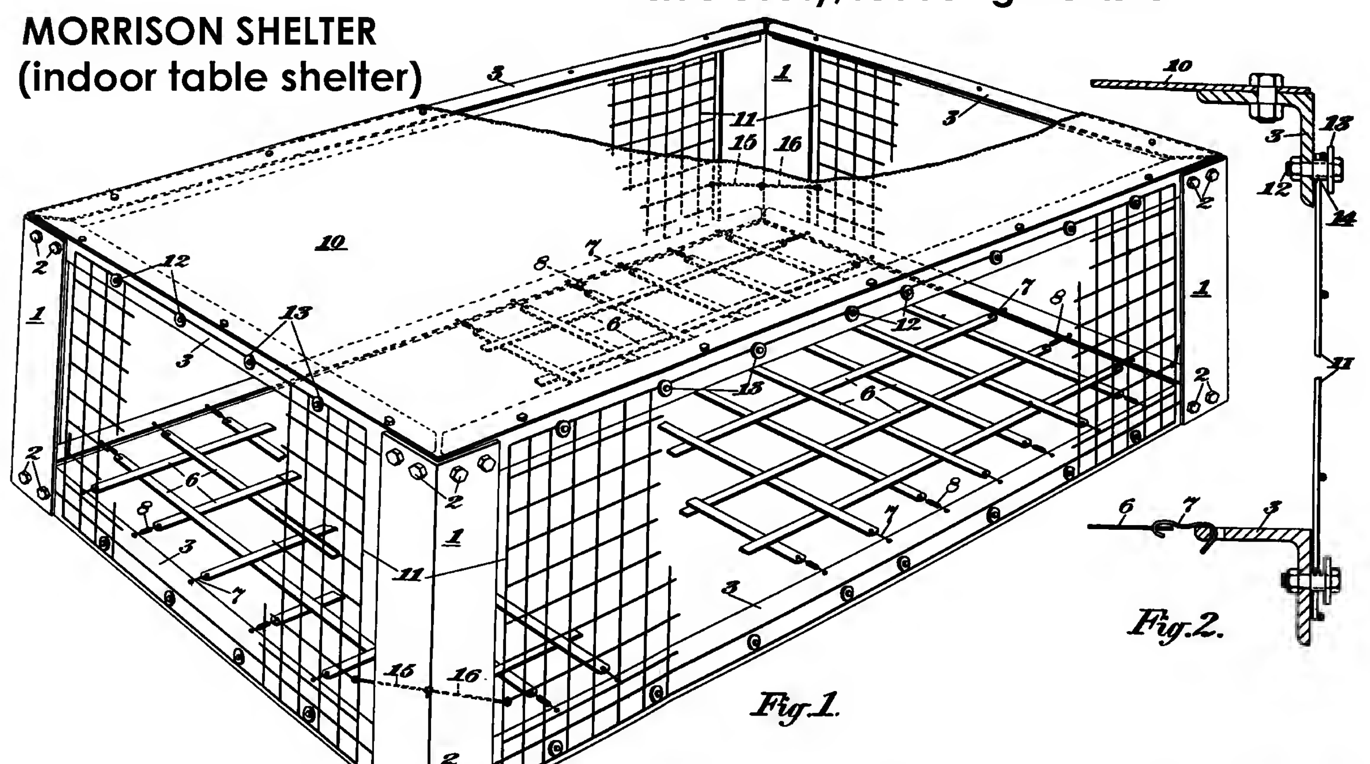
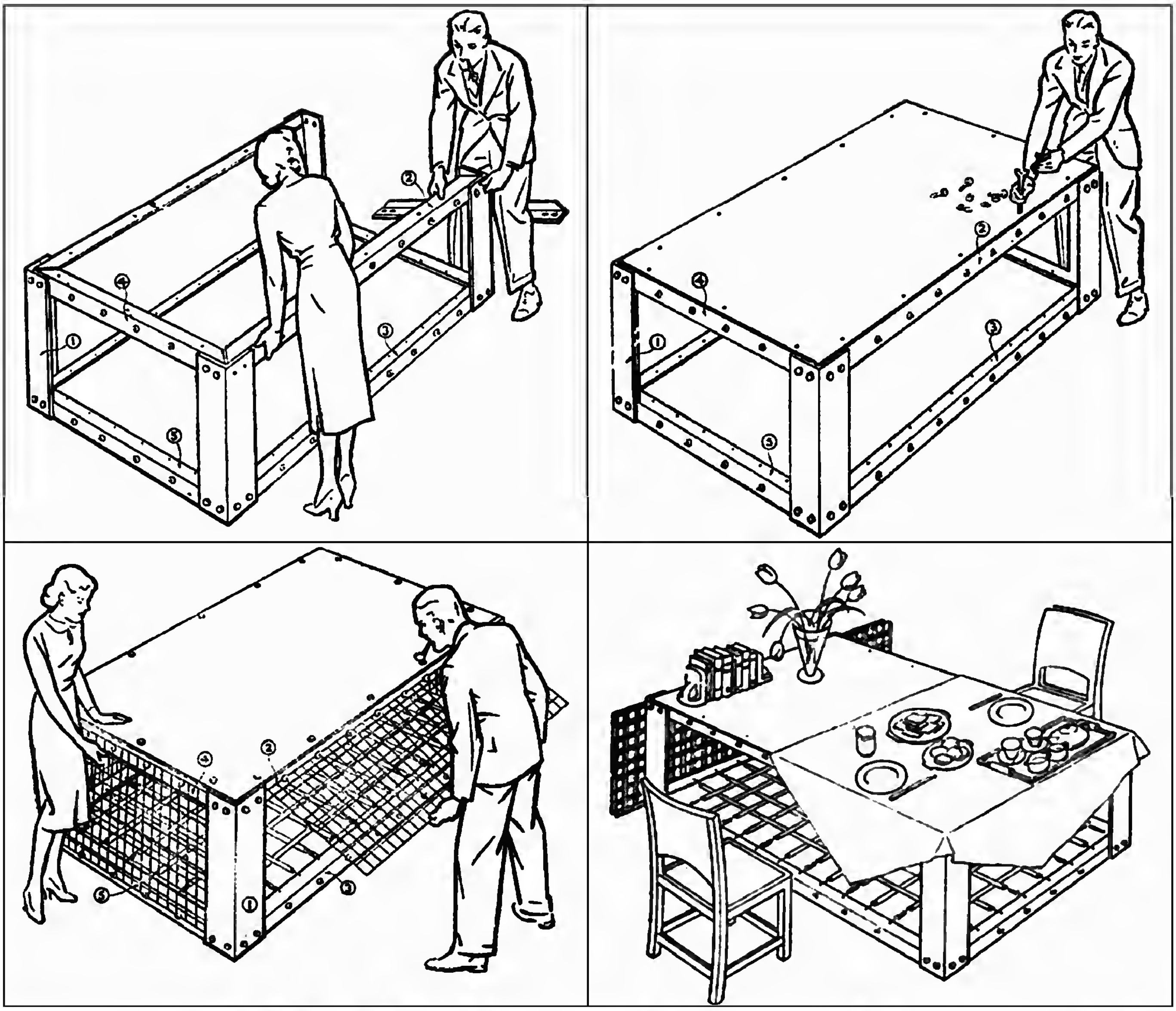


Table shelters allowed escape from any side easily, reducing fire risks

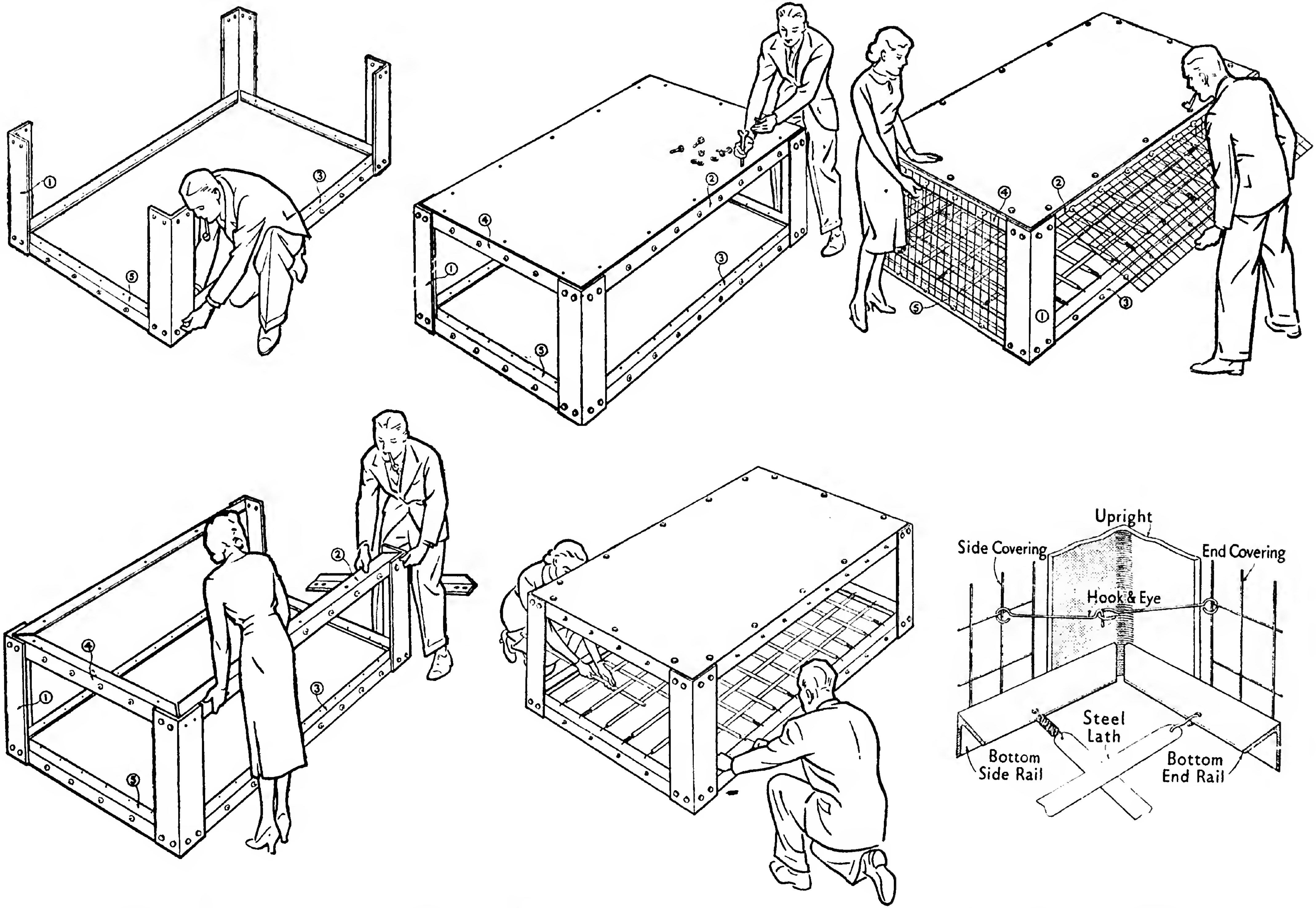


Patent specification by Prof. John Fleetwood Baker, Ministry of Home Security (National Archives HO 356/10)

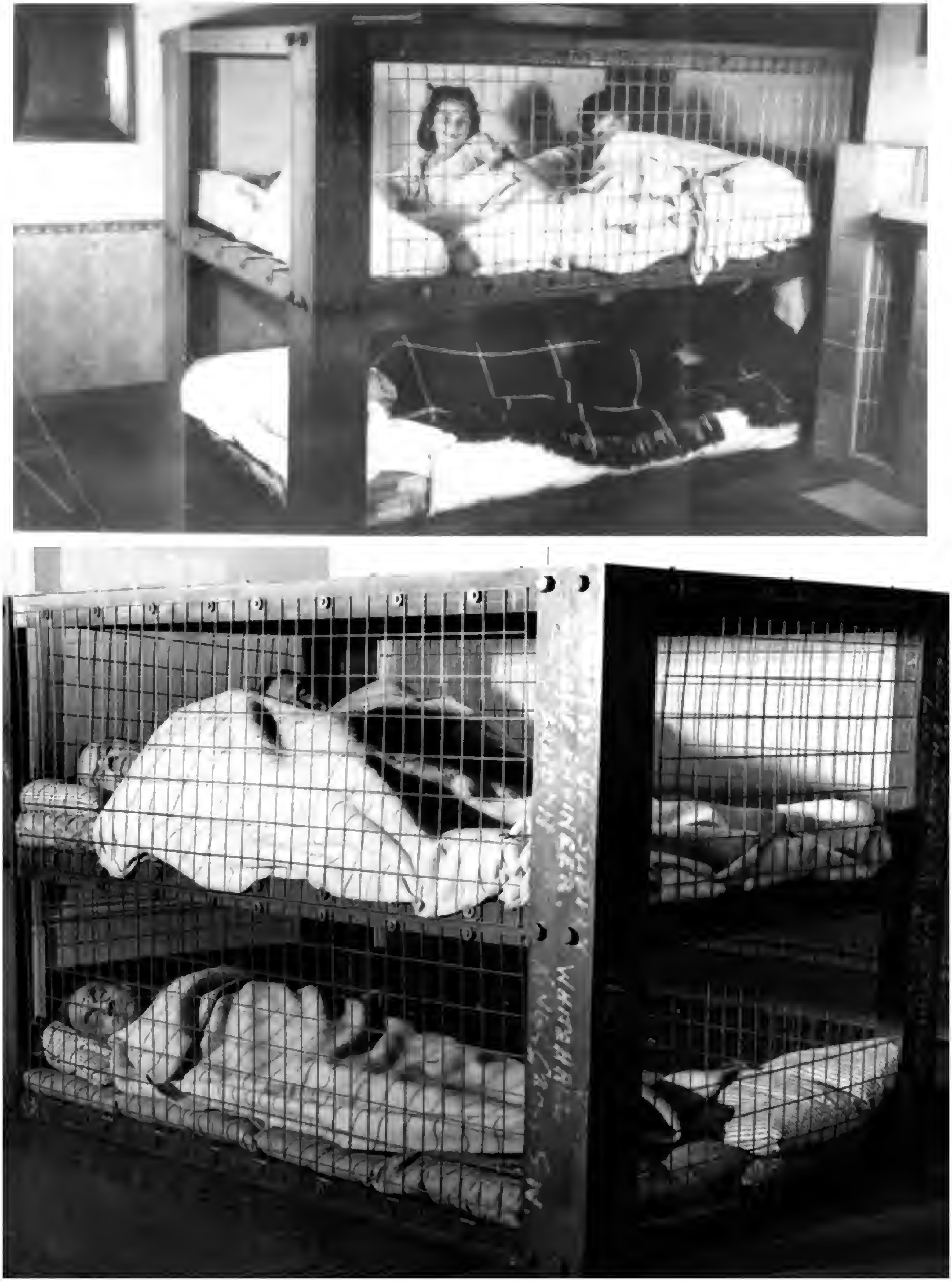


Structural Defense, 1945, by D. G. Christopherson, Ministry of Home Security, RC 450, (1946); Chapters VIII and IX (Confidential). Chapter VIII summarizes the literature on the design and types of British shelters and analyzes their effectiveness.

National Archives
HO 195/16



How to Put Up Your "Morrison" Steel Table Shelter, 1942



Two tier-Morrison shelters

SECRET.

W.P.(G)(41)7. COPY NO. 62

January 15th, 1941.

WAR CABINET.

AIR RAID SHELTER POLICY.

Memorandum by the Minister of Home Security.

---

6. Shelter in the home: The Anderson shelter was originally intended for indoor use but for a number of reasons including the danger of fire an outdoor variant was adopted. Experience has shown that the objections to the indoor use of the Anderson or somewhat similar shelter are not so serious as was thought and two designs have been produced which can be erected indoors without support. These new types, although they may give slightly less protection than a well covered Anderson shelter out of doors, would fill the needs of a large section of the public, especially the middle class. One design allows the use of the shelter as part of the furniture of the room.

7. I regard shelters of this type as of the first importance and wish to provide them on a big scale. Each shelter will use over 3 cwt. of steel and will allow at a pinch two adults and one to two children to sleep inside. For an outlay of about 65,000 tons of steel, as a first instalment, I could therefore produce 400,000 shelters with accommodation for at least 1,000,000 persons. I should wish to complete such a programme within the first three months of production and thereafter at a similar or increasing rate. From enquiries I believe that manufacture can be arranged provided steel is supplied and if the Cabinet approves my policy I shall require their direction that the steel be made available.

10. Conclusions.

I ask for a general endorsement of the policy I have outlined in this paper and in particular for the agreement of my colleagues:

(i) that proposals for building shelters of massive construction should be rejected;

(ii) that steel should be made available to carry out the programme outlined in paragraph 7 for the provision of steel shelters indoors;

(iii) that the limit of income for the provision of free shelter for insured persons should be raised from £250 to £350 per annum.

H.M.

MINISTRY OF HOME SECURITY.
January 15th, 1941.

National Archives
HO197/24

Morrison Shelters in Recent Air Raids.

A report of Ministry of Home Security experts on 39 cases of bombing incidents in different parts of Britain covering all those for which full particulars are available in which Morrison shelters were involved shows how well they have stood up to severe tests of heavy bombing.

All the incidents were serious. Many of the incidents involved direct hits on the houses concerned a risk against which it was never claimed these shelters would afford protection. In all of them the houses in which shelters were placed were within the radius of damage by bombs; in 24 there was complete demolition of the house on the shelter.

A hundred and nineteen people were sheltering in these "Morrisons" and only four were killed. So that 115 out of 119 people were saved. Of these only 7 were seriously injured and 14 slightly injured while 94 escaped uninjured. The majority were able to leave their shelters unaided.





ILLUSTRATION NO. 8.

The house in the upper photograph had a Government steel table shelter in a downstairs room and was blown up to reproduce the effect of a heavy bomb falling near. The whole house collapsed, burying the shelter under débris. In the lower photo the shelter can be seen still intact. It would have been possible for anyone in the shelter to get out unaided.

(Page 11 from the June 1941 UK Ministry of Home Security "Shelter at Home" handbook.)

Morrison indoor table shelter test by Ministry of Home Security, 1941: result shelter survived and occupants would have escaped unaided. (Source: "Shelter at Home", June 1941 handbook.)

Morrison shelter saves lives of Mr McGregor (pictured beside Morrison shelter), as well as his wife and lodger, in collapsed house, York 1942 air raid

Morrison shelter saves lives of Mr McGregor pictured beside Morrison shelter, as well as his wife and lodger, in collapsed house, York 1942 air raid

Number and Classification of Official Evacuees in Great Britain in 1939 and 1940

900,000 of the 1.5 million returned to the target areas after four months of war.	September, 1939		January, 1940	
	Number	Percentage Distribution	Number	Per cent of Those in September, 1939
1. Unaccompanied school children	826,959	56.1	457,600	55
2. Mothers and accompanied children	523,670	35.5	64,900	12
3. Expectant mothers	12,705	0.9	1,140	9
4. Blind persons, cripples, and other special classes	7,057	0.5	2,440	35
5. Teachers and helpers	103,000	7.0	46,500	45
Total	1,473,391	100.0	572,580	39

Source: R. M. Titmuss, *Problems of Social Policy* (London: H.M. Stationery Office, 1950), pp. 103 and 172.

Effectiveness of Some Civil Defense Actions in Protecting Urban Populations (u)

Appendix B of Defense of the US against Attack by Aircraft and Missiles (u)

ORO-R-17, Appendix B

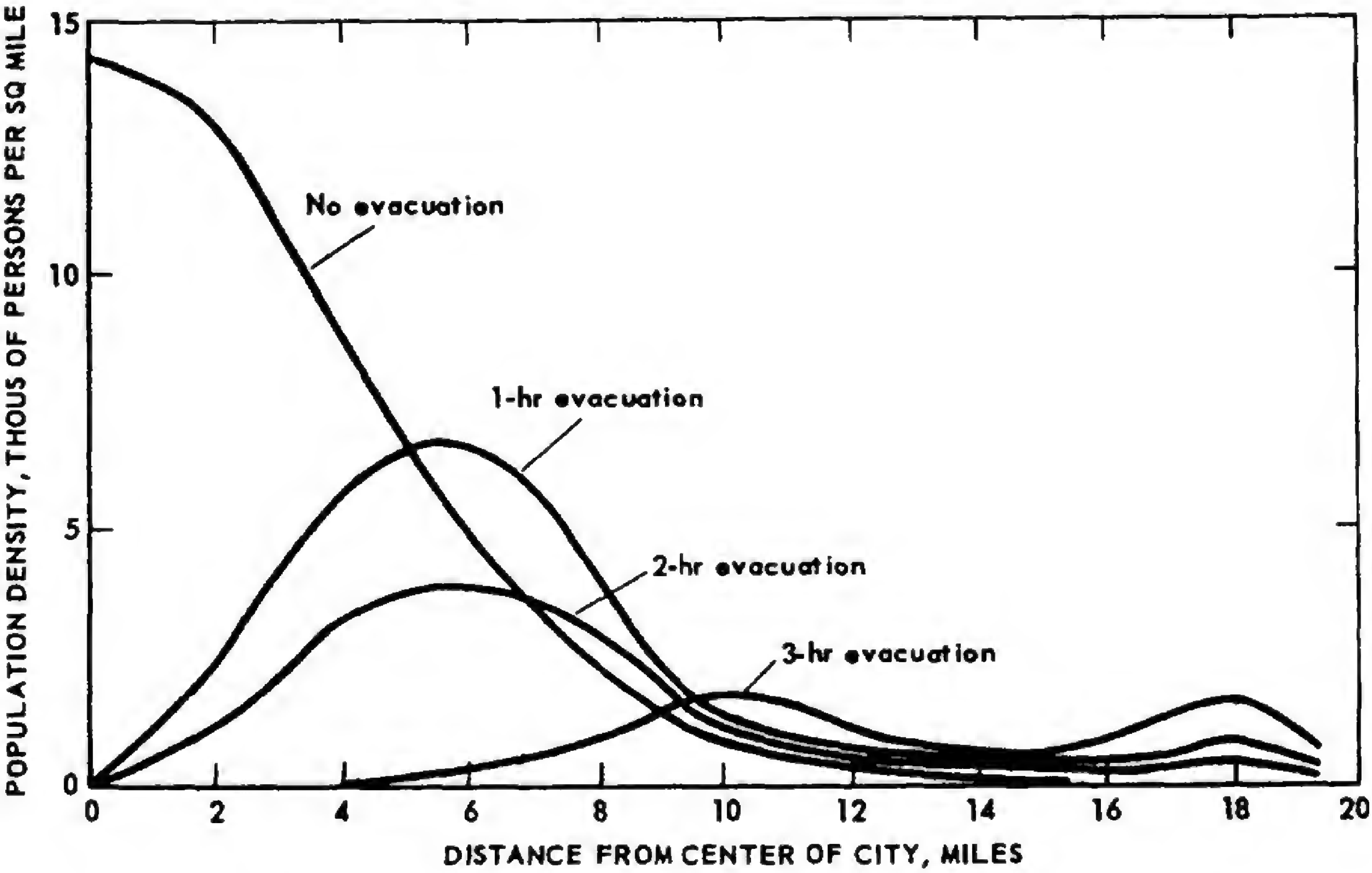


Fig. 10 — Population Density of Washington Target as Function of Distance from Center of City for Three Evacuation Times

Issued for the Ministry of Home Security
by the Ministry of Information

FRONT LINE

1940-41

The Official Story of the
CIVIL DEFENCE
of Britain

1942
London: His Majesty's Stationery Office

So far was all this from panic that it took three months for the population of the twenty-eight central boroughs to drop by about 25 per cent. from a little over 3,000,000 (the figure before heavy bombing began) to 2,280,000 at the end of November. In a group of the most heavily bombed eastern boroughs the pre-war population of 800,000 had fallen to 582,000 before the blitz began ; for four months it had dropped steadily to 444,000 ; by 31st December a fall of 23 per cent. These figures do not spell panic, and a further substantial fall in 1941, after continuous heavy raiding had ceased, completes the evidence that those who went did so in cold blood, for practical reasons as valid for their hard-pressed city as for their private selves.

But what did all this mean to the average Londoner ? In November, inner London (the county) contained some 3,200,000 people. Not more than 300,000 of these were in public shelter of any kind, half of that number at most in those larger shelters on which the limelight shone so exclusively. Nor is this all ; in domestic shelter (Andersons, small brick shelters and private reinforced basements) there were no more than

1,150,000 people. Thus of every hundred Londoners living in the central urban areas, nine were in public shelter (of whom possibly four were in "big" shelters), 27 in private shelter, and 64 in their own beds—possibly moved to the ground floor—or else on duty. Particular big shelters, and for a few nights the tubes, were overcrowded, but there was public shelter for twice the number who made use of it. In outer London, with a population of some 4,600,000, there were in November 4 per cent. in public shelter, 26 per cent. in domestic shelter, and 70 per cent. at home or on duty.

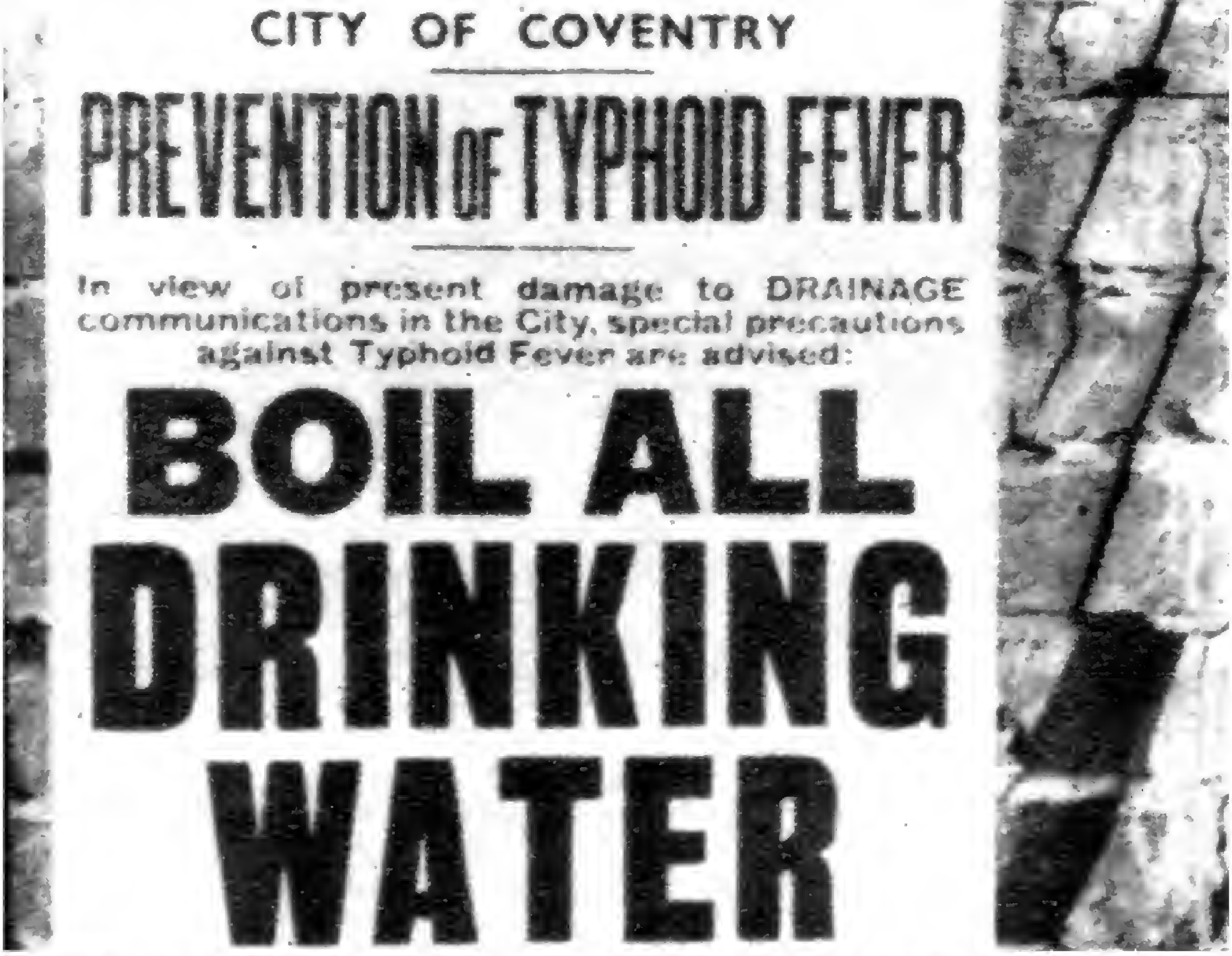
In the last great war there had been outbursts of hate against the distant enemy, and shops with German names had been wrecked. This time the citizens did not stop for such things. After the first shock of realisation they found no more need for direct recrimination than does the soldier. Like him, they got on with the job and waited their chance. Neither in this nor in any other way was there a sign of instability; no panic running for shelter, no white faces in the streets (though plenty of taut, grim ones), no nerve disease. In all London, the month of October saw but twenty-three neurotics admitted to hospital. The mind-doctors had rather fewer patients than usual.

BLOCKED ROADS. The morning of 12th May: each raid sets the police still another traffic problem.

ENORMOUS CRATERS. At the Bank, where the road collapsed into the subway beneath. A temporary bridge was thrown right across it.

The outcome may be seen in the following table, which shows coastal bombing to November, 1941, in round figures.

Town.		Number of Raids.	Civilians Killed.	Houses Damaged.
Fraserburgh	...	18	40	700
Peterhead	...	16	36	700
Aberdeen	...	24	68	2,000
Scarborough	...	17	30	2,250
Bridlington	...	30	24	3,000
Grimsby ...	...	22	18	1,700
Gt. Yarmouth	...	72	110	11,500
Lowestoft	...	54	94	9,000
Clacton ...	...	31	10	4,400
Margate	...	47	19	8,000
Ramsgate	...	41	71	8,500
Deal ...	...	17	12	2,000
Dover ...	...	53 (and shelling)	92	9,000
Folkestone	...	42	52	7,000
Hastings ...	...	40	46	6,250
Bexhill ...	...	37	74	2,600
Eastbourne	...	49	36	3,700
Brighton, Hove ...	}	25	127	4,500
Worthing	...	29	20	3,000
Bournemouth	...	33	77	4,000
Weymouth	...	42	48	3,600
Falmouth	...	33	31	1,100


CITY OF COVENTRY
PREVENTION OF TYPHOID FEVER
In view of present damage to DRAINAGE communications in the City, special precautions against Typhoid Fever are advised:
BOIL ALL DRINKING WATER

Aldwych tube London 21 Oct 1940: effective Blitz air raid shelter

THOSE WHO WENT TO SHELTERS began a new kind of night-life. Some took over the Tubes, camping out in this fashion—Elephant and Castle Station, 11th November, 1940.

In 12 months, 1940-1, the Blitz stray dog Rip (discovered by civil defence rescuers in Poplar, East London after an air raid) sniffed out 100 trapped casualties in London rubble.

Irma. Margaret Griffin used Irma and Psyche to find 233 trapped persons

STANFORD RESEARCH INSTITUTE

STANFORD, CALIFORNIA

June, 1953

Final Report

IMPACT OF AIR ATTACK IN WORLD WAR II:
SELECTED DATA FOR CIVIL DEFENSE PLANNING

Evaluation of Source Materials

By

Robert O. Shreve

SRI Project 669

Prepared for
Federal Civil Defense Administration
Washington, D. C.

Approved:

William J. Platt
William J. Platt, Chairman
Industrial Planning Research

Weldon B. Gibson
Weldon B. Gibson, Director
Economics Research Division

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 25 cents

Table 1

Report Outline - USSBS Project

IMPACT OF AIR ATTACK IN WORLD WAR II:
SELECTED DATA FOR CIVIL DEFENSE PLANNING

Division I - PHYSICAL DAMAGE TO STRUCTURES, FACILITIES, AND PERSONS

Volume 1 Summary of Civil Defense Experience
Volume 2 Analytical Studies (Restricted)
Volume 3 Causes of Fire from Atomic Attack (Secret) --VITAL!!

The documents which should be given wide distribution for civil defense use are listed below, with a brief description:

a. USSBS Reports

Effects of the Atomic Bomb on Hiroshima, Japan (3 volumes).

Effects of the Atomic Bomb on Nagasaki, Japan (3 volumes).

These reports constitute two case studies of atomic bombing. Civil defense planners should be aware of the facts these documents record in great detail. Their distribution to all civil defense planners and analysts is highly desirable.

-9-

Effects on Labor in Clydebank of Clydeside Raids of March 1941, (REN 234) USSBS Target Int.(REN 236) Ministry of Home Security

A study of the effects on labor of bombing in a town of 50,000 people in which 76% of houses were rendered uninhabitable, 73% of the population homeless. An equivalent of 65 city days was utilized in the reconstruction.

-22-

Ministry of Home Security
Effects of German Air Force Raids on Coventry (REN 441)

The city, the attack, casualties, repairs and reconstruction (cost), absenteeism, population movements, and housing occupancy. Six pages and charts and graphs. Twenty percent of houses rendered uninhabitable or destroyed, a total reconstruction cost of £ 3,492,000. Average time lost by worker after November raid was eleven days; average after April raid was 7 days. Nine percent of the workers evacuated to points within reach of the city.

An eminent chemist gives the facts about poison gas and air bombing

Breathe Freely!

THE TRUTH ABOUT POISON GAS

by

James Kendall

M.A., D.Sc. F.R.S.

Professor of Chemistry, University of Edinburgh

The civilian has been told that he will have to bear the brunt of another war, that within a few hours from the outset enemy bombers will destroy big cities and exterminate their inhabitants with high explosive, incendiary and gas bombs. What is the truth ?

Here, in this book, written in language everyone can understand, is the considered opinion of an authority on chemical warfare.

Breathe Freely !

THE TRUTH ABOUT POISON GAS

JAMES KENDALL

M.A., D.Sc., F.R.S.

Professor of Chemistry in the University of Edinburgh; formerly Lieutenant-Commander in the United States Naval Reserve, acting as Liaison Officer with Allied Services on Chemical Warfare

1938

CASUALTIES IN INITIAL GAS ATTACKS

Gas	*Date*	*Amount Used In Tons*	*Lethal Concentration **	*Non-fatal injuries*	*Deaths*
Chlorine	Apr. 22, 1915	168	5·6	15,000	5,000
Phosgene	Dec. 19, 1915	88	0·5	1,069	120
Mustard	July 12, 1917	125	0·15	2,490	87

(* mg/litre for 10 minutes exposure unprotected)

between September 15 and November 11, 1918, 2,000,000 rounds of gas shell, containing 4,000 tons of mustard gas, were fired against the advancing British troops; our losses therefrom were 540 killed and 24,363 injured. Gas defence had progressed to the point where it took nearly 8 tons of mustard gas to kill a single man !

The first salvo of gas shells often reaches the trenches before the occupants don their masks, whereas the Londoner will receive ample warning of the approaching danger.

The alarmist and the ultra-pacifist love to quote the fact that one ton of mustard gas is sufficient to kill 45,000,000 people. This would indeed be true if the 45,000,000 people all stood in a line with their tongues out waiting for the drops to be dabbed on, but they are hardly likely to be so obliging. One steam-roller would suffice to flatten out all the inhabitants of London if they lay down in rows in front of it, but nobody panics at the sight of a steam-roller.

Ever since the Armistice, three classes of writers have been deluging the long-suffering British public with lurid descriptions of their approaching extermination

These three classes are pure sensationalists, ultra-pacifists and military experts.

perpetrators of such articles may not recognize themselves that what they are writing is almost entirely imaginary, but they do want to get their manuscript accepted for the feature page of the *Daily Drivel* or the *Weekly Wail*. In order to do that, they must pile on the horrors thick, and they certainly do their best

The amount of damage done by such alarmists cannot be calculated, but it is undoubtedly very great.

poison gas has a much greater news value. It is still a new and mysterious form of warfare, it is something which people do not understand, and what they do not understand they can readily be made to fear.

The recent film *Things to Come*, in particular, has provided a picture of chemical warfare of the future which shows how simply and rapidly whole populations will be wiped out. Millions of people, perhaps, have been impressed by the authority and reputation of Mr. H. G. Wells into believing that this picture represents the plain truth.

Exhibit 'B' is the work of the ultra-pacifist. He abominates war and everything connected with war to such an extent that he paints a highly coloured picture of its horrors, in the most extreme Surrealistic style, with the object of frightening the public to the point where they will relinquish, in the hope of escaping war, even the right of self-defence. His motives may be praiseworthy, but his methods are to be deplored.

French family at Marbache, Meurthe et Moselle, France, September 1918. Gas masks were compulsory in the village, due to nearby gas attacks. Photo is the frontispiece of the October 1921 reprint of Will Irwin's book "The Next War" (Dutton, N.Y., 19th printing Oct 1921; first published April 1921.)

J. Davidson Pratt, "Gas Defence from the Point of View of the Chemist" (Royal Institute of Chemistry, London, 1937): "... during the Great War, French and Flemish ... living in the forward areas came unscathed through big gas attacks by going into their houses, closing the doors - the windows were always closed in any case - and remaining there..."

IF THE GAS RATTLES SOUND

Put on mask, holding your breath until mask is in position. Turn up collar. Put on gloves or keep hands in pockets. Take cover in nearest building quickly. Put up umbrella if you have one.

IF YOU GET GASSED

by Vapour Gases

1. Keep your mask on even if you feel discomfort.
2. If discomfort continues, go to First Aid Post.

by Liquid or Blister Gas

1. Dab, but *don't rub* the splash with your handkerchief. Then destroy the handkerchief.
2. Rub No. 2 Ointment well into place (buy a 6d. jar now from any chemist). In an emergency, chemists will supply Bleach Cream free.
3. If you can't get the Ointment or Cream within 5 minutes, wash the affected place with soap and warm water.
4. Take off *at once* any garment splashed with gas.

HOW TO PUT ON YOUR MASK

1. Hold your breath. 2. Hold mask in front of face, thumbs inside straps. 3. Thrust chin well forward into mask. Pull straps as far over head as they will go. 4. Run finger round face-piece taking care head-straps are not twisted.

War Gas Leaflet (HO 186/2247)


Hand pumped
(asthmatic)
Baby's
Hospital patient's
Police
/warden
Civilian
Soldier's
until 1942
Small child's
(mickey mouse)

London 1941 baby gas mask drill

OFFICIAL INSTRUCTIONS ISSUED BY THE MINISTRY OF HOME SECURITY

What to do about GAS

In a gas attack, first put on your own mask, then you will be better able to help baby.

HINTS TO MOTHERS

★ Learn to put on baby's gas helmet quickly, while wearing your own mask. Your Health Visitor will show you how. If you don't know her address ask at Town Hall or at the Child Welfare Centre.

★ With more than one baby you need help. Arrange with a neighbour, or find out if your local W.V.S. has a Housewives' Service.

★ Toddlers soon learn to put on their own masks. Let them make a game of it and they will wear their gas masks happily.

MAKE SURE YOUR FAMILY HAVE THEIR GAS MASKS WITH THEM NIGHT & DAY

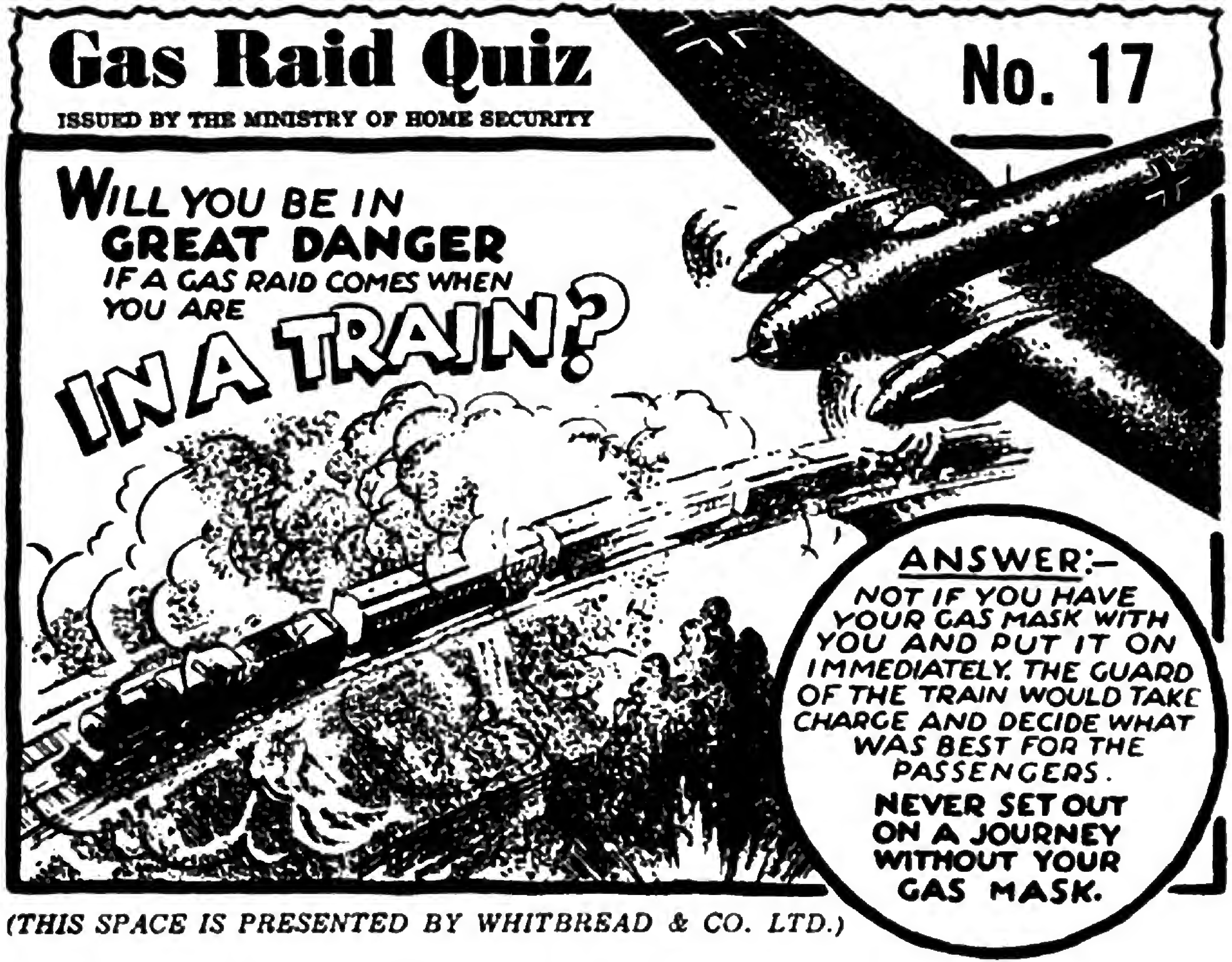
Gas Helmets for Babies (HO 186/2247)

London baby gas mask tests (3 March 1939)

Hitler will send no warning –

so always carry your gas mask

ISSUED BY THE MINISTRY OF HOME SECURITY



Gas Raid Quiz Leaflet (HO 186/2247)

Printed for the War Cabinet. January 1941.

SECRET. Copy No. 28

W.P. (41) 15.
January 24, 1941.

TO BE KEPT UNDER LOCK AND KEY.

It is requested that special care may be taken to ensure the secrecy of this document.

WAR CABINET.

ANTI-GAS PRECAUTIONS.

Memorandum by Home Secretary and Minister of Home Security.

FOLLOWING the discussion at the War Cabinet* on the 20th January, 1941, I circulate the following note about anti-gas measures for the civil population. The note has been drawn up on the assumption that there should be no press and broadcast publicity about anti-gas precautions. I appreciate that there are good reasons for such a course of action, but I feel bound to say that the absence of publicity will make it more difficult to secure a rapid and widespread improvement in the preparedness of the civil population to meet a sudden gas attack. The value of a respirator, for example, lies only partly in the efficiency of the respirator itself. The balance—and no small balance—depends on the extent to which the public are practised in the habit of putting it on quickly and wearing it.

Even with the aid of advance publicity it is impossible to guarantee that the first onset of a gas attack will not result in casualties. The risk must inevitably be increased—possibly quite seriously in view of the immunity we have hitherto enjoyed—if there is no public warning of the increased likelihood of gas attack in the near future. I suggest, therefore, that the War Cabinet should review their policy in this matter.

H. M.

Home Office, January 24, 1941.

NOTE.

Personal Protection.

(a) *General public.*

1. Every member of the public should be in possession of a respirator. All respirators have been fitted with an additional filter known as "Contex" to increase their protection against particulate gases, *i.e.*, arsenical smokes. There are over 10 million respirators in national reserve in addition to 3 million reserves in the hands of local authorities.

2. In March 1940 arrangements were made through the Wardens' organisation for a special inspection of respirators in the hands of the public. Local authorities were then asked to institute a system of inspection by Wardens at

* W.M. (41) 8, item 4.

regular intervals. The issue of "Contex," which began in May and continued until September, gave a special opportunity for inspection by Wardens, and there is reason to believe that this inspection was largely carried out.

3. The number of faulty respirators reported at the March 1940 inspection was surprisingly small, and the number of unserviceable respirators returned by local authorities in the period April to December 1940, was at the rate of less than 4 per cent. a year.

as the view has been taken that it was unnecessary to have decontamination squads always standing by. They are in the main drawn from the men belonging to the cleansing departments of the local authorities.

At present these men are reserved by reason of their primary occupation at 25, but it is proposed by the Man-Power Committee and the Ministry of Labour and National Service to raise the age to 35. It will be necessary therefore that there should be some deferment of the calling-up of a proportion of the men under 35, and discussions are already taking place on this with the Ministry of Labour.

Anti-Gas Precautions in Shelters.

17. In July 1940, instructions were issued that arrangements should be made for securing that public shelters could be made gas-proof. Now that shelters are being used for sleeping, adequate ventilation is of the first importance. It is impracticable to reconcile this with efficient gas-proofing. Local authorities are therefore being informed that further steps to provide gas-proofing in naturally ventilated shelters should not be taken for the present and that reliance must be placed on the respirator as the first line of defence.

Tel. No.: VICtoria 6826

Any communication on the subject of this letter should be addressed to—

The Under Secretary of State,
Home Office (A.R.P. Dept.),
Horseferry House,
Thorney Street,
London, S.W.1.

and the following number quoted:—
701,602/109

HOME OFFICE,
Air Raid Precautions Dept.,
HORSEFERRY HOUSE,
THORNEY STREET,
LONDON, S.W.1.

31*st December*, 1937.

Sir,

Experiments in Anti-Gas Protection of Houses

I am directed by the Secretary of State to transmit, for the information of your Council, the annexed Report describing in detail the experiments to which reference was made by the Parliamentary Under Secretary of State in his speech on the second reading of the Air Raid Precautions Bill in the House of Commons on the 16th November.

The experiments were conducted by the Chemical Defence Research Department under the aegis of a special Sub-Committee of the Chemical Defence Committee. That Sub-Committee was composed of eminent experts not in Government employment, and included a number of distinguished University professors and scientists.

I am,
Sir,
Your obedient Servant,
R. R. Scott.

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The Town Clerk.
The Clerk to the District Council.

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PROTECTION AGAINST GAS

REPORT OF EXPERIMENTS CARRIED OUT BY THE CHEMICAL DEFENCE RESEARCH DEPARTMENT

Handbook No. 1 issued by the Air Raid Precautions Department of the Home Office describes the steps which the public are advised to take in order to protect themselves against the effects of any chemical warfare gases which might be employed by enemy aircraft in time of war.

The gist of these recommendations is:—

First, to go indoors.

Secondly, to arrange for the room into which you go to be made as gas-proof as possible.

Thirdly, to take with you the respirator which will have been issued to you.

Whilst it has never been claimed that any one of these steps by itself will make an individual completely safe, experiments and trials have shown that each of these measures is by itself of considerable value and that when all of them are adopted a very high degree of protection is obtained. An outline is given below of certain typical experiments which have been carried out.

These particular experiments were carried out with four different types of actual war gas. The first four experiments to be described will show the degree of protection that is obtained from each type of gas merely by going indoors and shutting the doors and windows.

As explained in Handbook No. 1*, a chemical warfare gas may be dropped from aircraft either as spray or in bombs. In the former case the liquid drops fall like rain, and it is obvious that by going indoors the public will avoid them. On the other hand, if gas bombs are dropped, people who have gone indoors will avoid being splashed by the chemical in the bomb, and even in an ordinary room they will receive some protection from the gas cloud. The amount of protection obtained in a house which has not been treated in any way can be gathered from the following experiments.

(a) *Protection obtained in a house which has not been treated in any way.*

The house employed was a gamekeeper's cottage with three rooms on the ground floor and three rooms upstairs. It had been unoccupied for about 15 years but was in a reasonable state of repair. It was to a large extent sheltered by belts of

* A.R.P. Handbook No. 1, "Personal Protection against Gas", price 6d. (8d. post free): published by H.M. Stationery Office (see back page).

trees which reduced the strength of the wind in the vicinity of the cottage to about one-eighth of that in the open. In this respect therefore the location of the cottage resembled a house in a town. In one experiment over a ton of actual chlorine gas was released 20 yards from the house so that the wind carried it straight on to the unprotected room. A very strong gas cloud was thus maintained outside the house for about 40 minutes, during which time the gas gradually penetrated to the inside. A fire was burning in the hearth the whole time, and the only measures taken to exclude the gas consisted of closing the doors and windows in the normal way.

Human beings who occupied this unprotected room found that gas penetrated slowly into the room, and after about seven minutes is became necessary for them to put on their respirators. Had these men been outside the house, they would have been compelled to put on their respirators immediately, since otherwise the very intense gas cloud would have caused instantaneous incapacitation and ultimate death.

If the gas, which with its containers weighed about 2½ tons, had been released more quickly, the strength of the gas cloud would have been greater but the time during which the house was enveloped by it would have been correspondingly shorter.

It is important to appreciate properly the severity of this trial. The quantity of gas concentrated on this house could under practical conditions only be obtained by several large bombs dropping very close to the building. The period of exposure to the maximum effects of the gas was also many times longer than would normally be experienced under most practical conditions, since the initial cloud from a gas bomb soon begins to be diluted and dispersed by the action of even quite moderate winds. It is clear that conditions similar to those of the experiment are extremely severe, and are such as would be likely to occur very rarely indeed and to a very small number of houses.

It should also be noted that the cottage used in this experiment had no carpets or other floor coverings. Most of the gas which leaked in came through the spaces between the floor boards, and it is therefore clear that much less would have got into an ordinary room in which there was a carpet, linoleum, or a solid floor.

In another experiment the house was surrounded at a distance of 20 yards by large shallow trays which were filled with mustard gas, the trays being spaced a few yards apart. By this means the vapour given off by the mustard gas was carried on to the house no matter how the direction of the wind varied. As the weather at the time was not very warm, the conditions of the experiment were made more severe by producing a fine spray of mustard gas at a point 10 yards to windward of

the house so that the house was enveloped in the resultant cloud of mustard gas for a period of an hour. The cloud produced in this way was about a hundred times as strong as that caused by the evaporation of the mustard gas from the trays. Animals were placed in an unprotected room in the house and remained there during the spraying period and for a further 20 hours while the house was subjected to the vapour of mustard gas given off from the trays. Observations made upon the animals during the three subsequent days and also post mortem examination showed that none of them was seriously harmed by the mustard gas.

The third type of gas used was tear gas. In this experiment the same cottage was enveloped for an hour in an intense atmosphere of tear gas produced by spraying the gas into the air at a point 10 yards upwind of the house. Men who were stationed 200 yards downwind from the house and in the track of the gas cloud were incapacitated in about a minute, and in some cases in 20 seconds. On the other hand, men who occupied rooms in the house which had received no treatment beyond the closing of the windows and doors found no need to put on their respirators for the first 13 minutes. The tear gas gradually penetrated into these unprotected rooms, although after three-quarters of an hour the strength of the gas inside the house was still very much less than that outside.

In the fourth experiment the cottage was enveloped for 20 minutes in a dense cloud of arsenical smoke. Men occupying an unprotected room of the house found that the arsenical smoke penetrated into the room, but the strength of the cloud inside was much less than that outside. When Civilian respirators were worn in this room, complete protection was obtained. Men who were stationed 200 yards downwind of the house and in the path of the gas cloud were rapidly affected, but when they wore Civilian respirators no effects were felt.

The above four examples clearly demonstrate that, apart from the protection which a house provides against falling airplane spray, some measure of protection is afforded even by an ordinary unprotected room against gas clouds such as are produced by bombs close to the building.

(b) *Protection afforded by a house treated in accordance with Air Raid Precautions Handbook No. 1.*

A brief account will now be given of four further experiments with the same four war gases in order to illustrate the added protection which can be obtained by treating a room in accordance with the instructions given in Air Raid Precautions Handbook No. 1. These experiments were also conducted with the cottage already mentioned. The room selected for treatment was situated on the ground floor on the windward side

of the house so that it was subjected to the full effect of the gas and the wind. It measured about 12 feet square. The Air Raid Precautions instructions for excluding gas were carried out by unskilled men, the official procedure being rigidly followed. As the house was not provided with carpets or other floor covering, it became necessary to seal up the joints between the boards over the whole of the floor of the selected room. This was done by pasting strips of paper along the joints between the floor boards. Some of these strips became displaced by the boots of the men who were inside the room, and an appreciable leakage of gas into the room undoubtedly occurred due to this cause. Two tons of chlorine were released 20 yards from the house, the time of emission being an hour. Animals were placed in the house, some in the " gas protected " room and others in rooms which had received no such treatment. The latter set of animals were killed by the gas which penetrated into the unprotected rooms under these very severe conditions. The animals in the " gas protected " room, however, were unaffected and remained normal, notwithstanding the severity of the trial.

An experiment with mustard gas, similar to that already described, was also carried out after the ground floor room on the windward side of the house had been treated in accordance with the Air Raid Precautions Department's procedure. Animals were placed in the room, which was then subjected to the same exposure of mustard gas spray and vapour as before. At the end of 20 hours the animals were removed and a most thorough examination of them showed no evidence of the effects of the gas at all. Animals placed outside the house during the first hour of the experiment were, of course, very seriously affected. The amount of mustard gas penetrating into the room was also measured by chemical methods and it was found that the amount of gas inside the room was so small that a man could have remained there for the whole 20 hours without its being necessary for him to wear a respirator and without any subsequent ill-effects.

The experiment with tear gas previously described was also performed against the " gas protected " room. A number of men occupied this room and found they were able to remain there without its being necessary for them to put on their respirators at any time during the hours that this very severe experiment lasted.

An experiment with arsenical smoke, similar to that already described, was also carried out against the " gas protected " room. The occupants found that the arsenical smoke penetrated the room to an extent which caused some irritation of the nose and throat and eventually rendered the wearing of respirators desirable to ensure comfort. After putting on the respirator, no

discomfort was felt throughout the remainder of the experiment. Men who left the " gas protected " room wearing their Civilian respirators were able to traverse the densest part of the cloud without discomfort. Under these severe conditions the presence of the arsenical smoke could be detected, but the effects were insignificant.

It is important to appreciate fully the severity of the conditions imposed in the two trials with arsenical smoke. A very high concentration of the irritant smoke was maintained around the house for 20 minutes. Under practical conditions such a high concentration could be produced only by a large and efficiently designed bomb falling close to the building, and then only for a short period. The conditions of the trials were therefore extremely severe and represent a situation which would only rarely be met, and in which only a small number of houses would be involved.

From this second series of experiments it will be seen that treating a room in accordance with the recommendations of the Air Raid Precautions Department does reduce very considerably the amount of gas penetrating into the room, and that a room so treated is correspondingly safer than a room which has received no such treatment.

Indeed, in the case of the experiments with mustard gas and tear gas, the amount of gas which was able to penetrate into the gas protected room was so small that no further measures of protection were necessary.

In the experiment with chlorine, although the amount of gas which entered the treated room was insufficient to injure the animals, human beings who occupied the room during this extremely severe test could smell the gas. They were provided with Civilian respirators, and they found that by putting these respirators on they were completely protected against every trace of gas. Some of these individuals then left the " gas protected " room, passed out of the house, and traversed the lethal cloud of gas which enveloped it. Although they deliberately stood in the densest part of the cloud for some minutes, no trace of the gas passed through their respirators.

Similarly the experiments with arsenical smoke show that although, under the most severe conditions, the cloud may penetrate into the " gas protected " room in sufficient quantity to be detected, or even to cause some irritation, the effects are materially reduced in a room so treated. It is also demonstrated that wearing a Civilian respirator affords complete protection against any smoke which may gain access to the room. The respirator also enabled individuals to pass through an extremely dense cloud of arsenical smoke in complete safety.

The experiments which have been outlined in this statement were purposely designed to represent the most severe conditions likely to be met. The results all combine to show that if the instructions given in Air Raid Precautions Handbook No. 1 are carried out a very high standard of protection is obtained. With regard to the first precaution it has been shown that going indoors and closing the doors and windows affords some measure of protection, even though the room occupied has not been specially prepared. In these circumstances there is ample time to put on the respirator at leisure if this should be necessary. If the second precaution of rendering the room as gas-proof as possible has been carried out, then the occupants will normally be able to remain in complete safety and comfort without further protection. Under the most severe conditions sufficient gas may penetrate such protected rooms to be recognized or even to cause slight irritation. When this occurs the respirator can be put on though in many cases this will be as a matter of convenience and extra precaution rather than real necessity. With regard to the Civilian respirator it has been shown that this will, in conjunction with the above precautions, provide complete safety for any period for which it is likely to be required. It has further been demonstrated that this respirator will enable the wearer to reach a place of safety even if he should for a time be exposed to the most dangerous situation—for example if he is caught out of doors in a gas cloud, or if his gas-protected room becomes damaged and he is compelled to seek shelter elsewhere.

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HOME OFFICE

SCIENTIFIC INTELLIGENCE OFFICERS'

OPERATIONAL NOTES

RESTRICTED

Notes on BW and CW

General

Toxicological warfare can consist either of a tactical attack with chemical weapons producing an immediate incapacitating effect, or of a strategic attack with biological weapons which have a delayed effect.

The new Civilian Respirator (C7), with pneumatic tube face fitting which is comfortable for long periods of wearing, affords excellent protection against BW and CW attacks.

BW

In attacks on populations, since the airborne hazard is the main one, only agents of high infectivity and high virulence (i.e. a small number of organisms required to produce infection and cause severe illness), combined with viability for many hours in the atmosphere, are likely to prove effective.

Some representative pathogenic micro-organisms

Bacterial	Anthrax	(lethal, very persistent spores but relatively low infectivity)
	Brucellosis	(incapacitating)
	Tularaemia	(incapacitating or lethal)
	* Rickettsial	Q fever (like typhus)
	* Viruses	Encephalomyelitis (brain fever)
		Smallpox (epidemic)

ON23:2

Personal protection

Respirators and discardible covers for head and body may be used. Extreme personal cleanliness is necessary. Total dosage can be reduced very considerably in a closed room in a house by sealing window cracks and door gaps before the arrival of contamination and ventilating the room fully as soon as it has passed.

Decontamination

Where appropriate the following measures may be taken:-

(a) weathering for a few days will destroy most bacterial agents other than anthrax spores
(b) use of bleach solution
(c) scattering petrol and firing it on open contaminated ground.

CW

Mustard gas and anticholinesterase agents (persistent and non-persistent nerve gases) are the CW agents most likely to be encountered in a tactical battle.

Building/ Vehicle Type	Air Exchange Rate (ACH)	Time Building Is Exposed (hr.)	Time of Occupancy from Cloud Arrival (hr.)	Shielding Factor
Residential Building (Windows Closed)[1]	0.53	0.25	0.25	15.8
	0.08-3.24	0.25	0.25	100.7-3.2
Residential Building (Windows Open)[1]	6.4	0.25	0.25	2.0
Nonresidential Building[1]	1.285	0.25	0.25	6.9
	0.3-4.1	0.25	0.25	27.3-2.7
Vehicle[1]	36	0.25	0.25	1.1
Mass-Transit Vehicle[1]	1.8-5.6	0.25	0.25	5.1-2.2
Stationary Automobile[2]**:**				
Windows Closed/No Ventilation	1.0-3.0	0.25	0.25	8.7-3.4
Windows Closed/Fan On Recirculation	1.8-3.7	0.25	0.25	5.1-2.9
Windows Open/No Ventilation	13.3-26.1	0.25	0.25	1.4-1.2
Windows Open/Fan On Fresh Air	36.2-47.5	0.25	0.25	1.1

1 Ted Johnson, A Guide to Selected Algorithms, Distributions, and Databases used in Exposure Models Developed by the Office of Air Quality Planning and Standards (Chapel Hill, NC: TRJ Environmental, Inc., 22 May 2002), http://www.epa.gov/ttn/fera/data/human/report052202.pdf. Accessed 8 January 2008.

2 J. H. Park et al., "Measurement of Air Exchange Rate of Stationary Vehicles and Estimation of In-Vehicle Exposure," Journal of Exposure Analysis & Environmental Epidemiology 8, no. 1 (January–March 1998):65-78.

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DEPARTMENT OF ENERGY

ORNL/TM-10423

Technical Options for Protecting Civilians from Toxic Vapors and Gases

C. V. Chester

Date Published - May 1988

Prepared for
Office of Program Manager
for
CHEMICAL MUNITIONS
Aberdeen Proving Grounds, Maryland

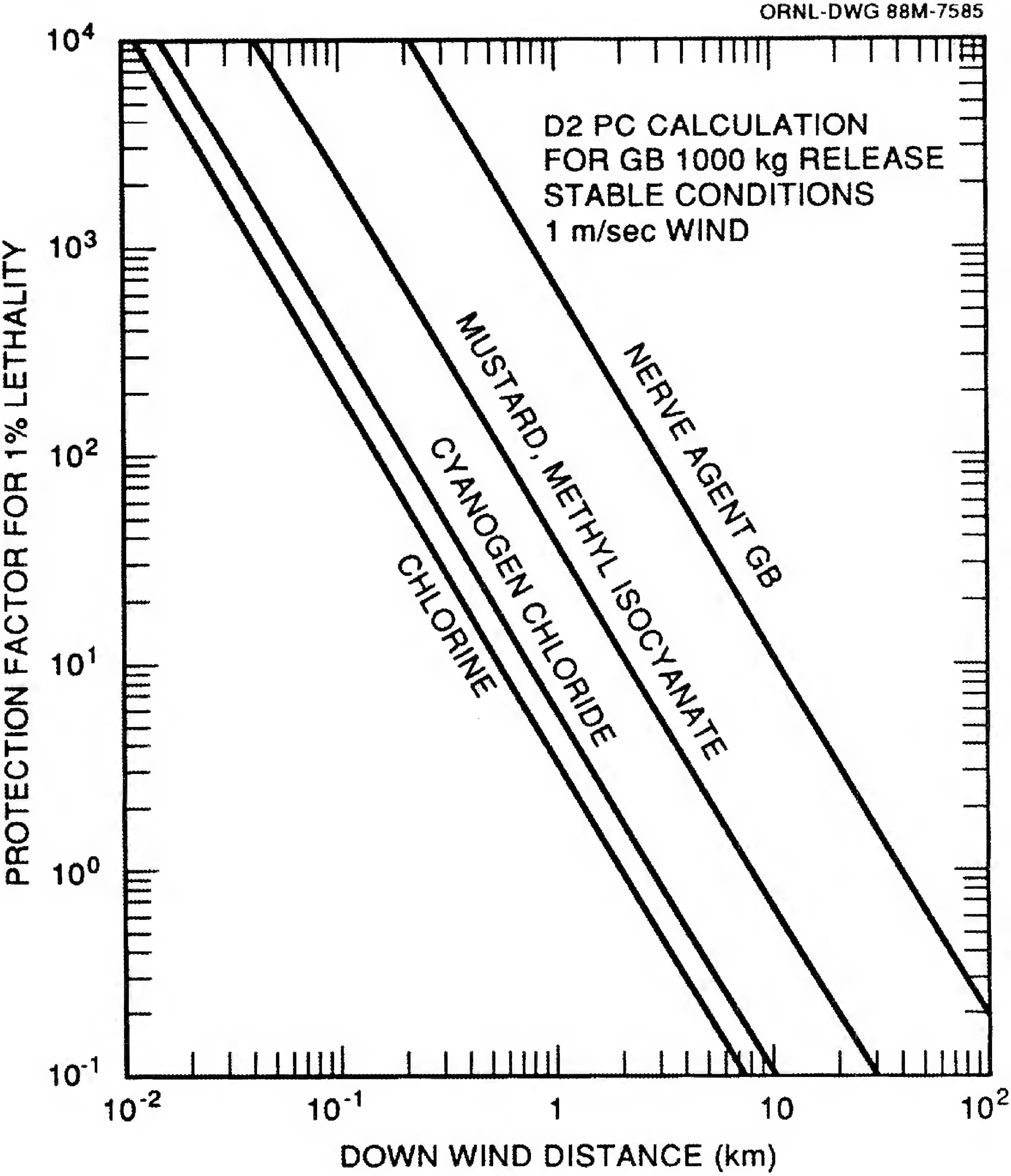

Fig. 1 Dose vs Downwind Distance for Some Very Toxic Gases

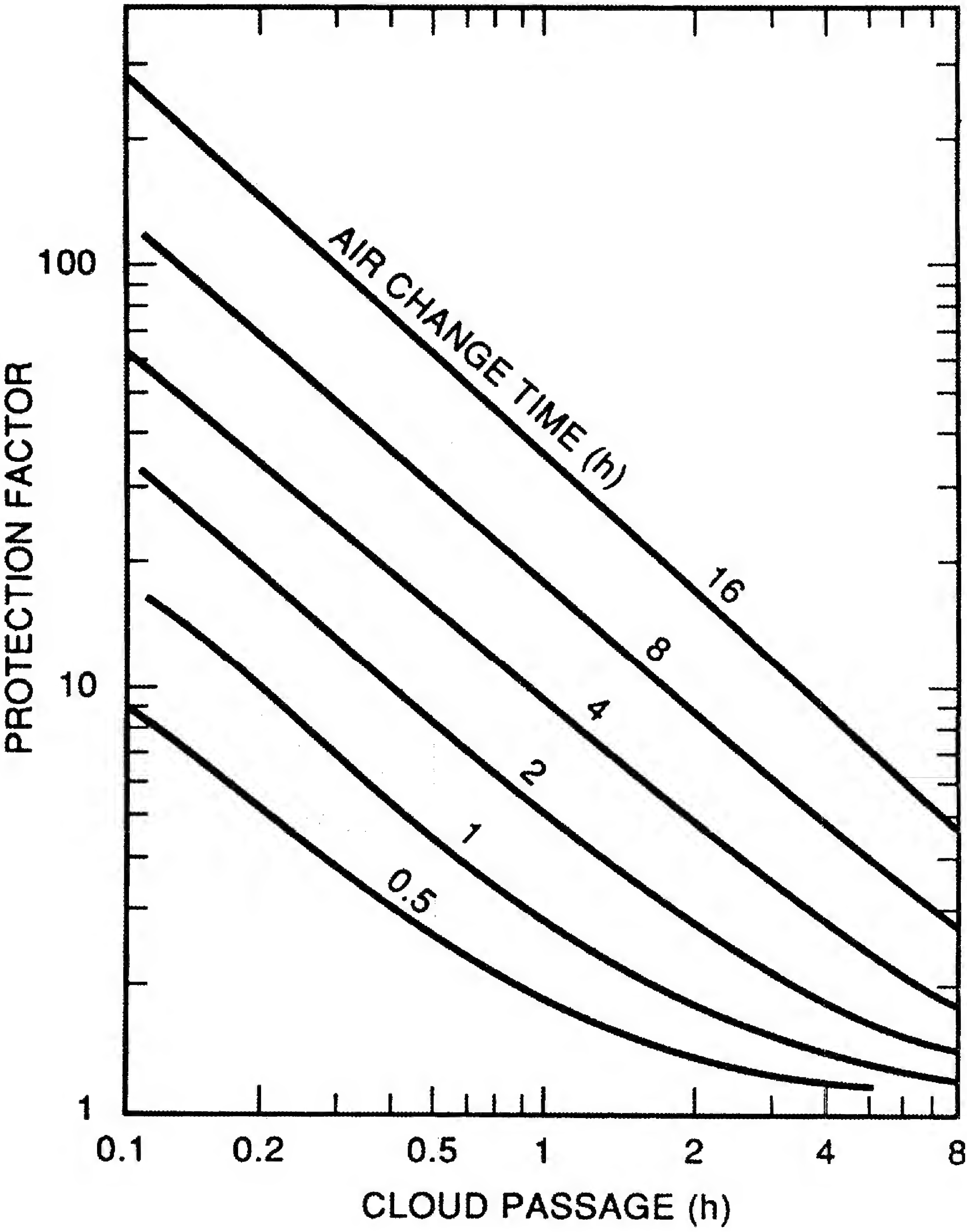

Fig. 2 Protection Factor of Leaky Enclosures

ORNL-DWG 88M-7581

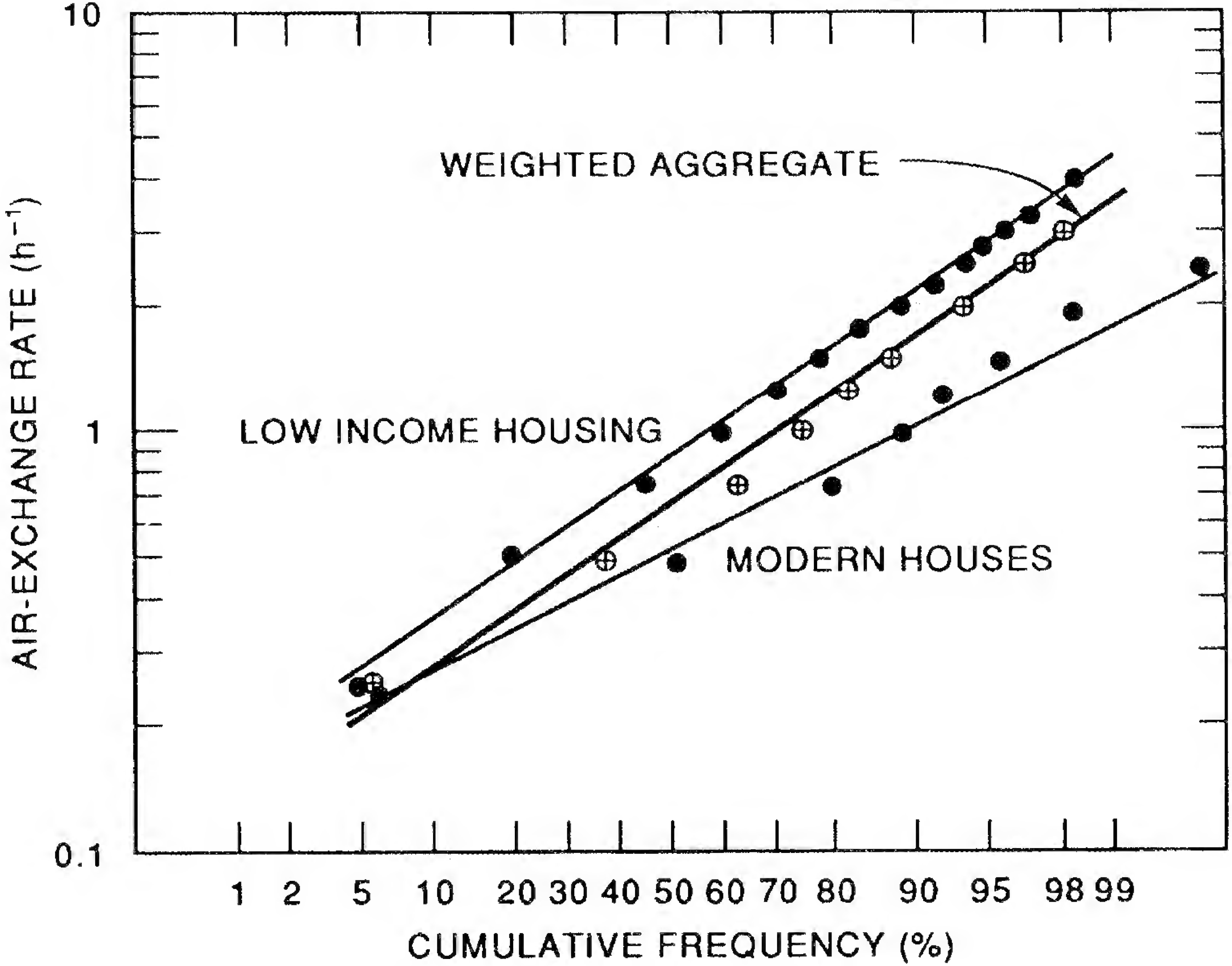

Fig. 3 Infiltration Rates of American Residences

ORNL/TM-2001/154

Energy Division

Will Duct Tape and Plastic Really Work? Issues Related To Expedient Shelter-In-Place

John H. Sorensen
Barbara M. Vogt

Date Published—August 2001

Prepared for the
Federal Emergency Management Agency
Chemical Stockpile Emergency Preparedness Program

Prepared by
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Although vapors, aerosols, and liquids cannot permeate glass windows or door panes, the amount of possible air filtration through the seals of the panes into frames could be significant, especially if frames are wood or other substance subject to expansion and contraction. To adequately seal the frames with tape could be difficult or impractical. For this reason, it has been suggested that pieces of heavy plastic sheeting larger than the window be used to cover the entire window, including the inside framing, and sealed in place with duct or other appropriate adhesive tape applied to the surrounding wall.

Another possible strategy would be to use shrink-wrap plastic often used in weatherization efforts in older houses. Shrink-wrap commonly comes in a 6 mil (0.006-in.) thickness and is adhered around the frame with double-faced tape and then heated with a hair dryer to achieve a tight fit. This would likely be more expensive than plastic sheeting and would require greater time and effort to install. Because double-faced tape has not been challenged with chemical warfare agents, another option is to use duct tape to adhere shrink-wrap to the walls. Currently, we do not recommend using shrink-wrap plastics because of the lack of information on its suitability and performance.

3. WHY WERE THESE MATERIALS CHOSEN?

Duct tape and plastic sheeting (polyethylene) were chosen because of their ability to effectively reduce infiltration and for their resistance to permeation from chemical warfare agents.

3.1 DUCT TAPE PERMEABILITY

Work on the effectiveness of expedient protection against chemical warfare agent simulants was conducted as part of a study on chemical protective clothing materials (Pal et al. 1993). Materials included a variety of chemical resistant fabrics and duct tape of 10 mil (0.01-in.) thickness. The materials were subject to liquid challenges by the simulants DIMP (a GB simulant), DMMP (a VX simulant), MAL (an organoposphorous pesticide), and DBS (a mustard simulant). The authors note that simulants should behave similarly to live agents in permeating the materials; they also note that this should be confirmed with the unitary agents. The study concluded that "duct tape exhibits reasonable resistance to permeation by the 4 simulants, although its resistance to DIMP (210 min) and DMMP (210 min) is not as good as its resistance to MAL (>24 h) and DBS (> 7 h). Due to its wide availability, duct tape appears to be a useful expedient material to provide at least a temporary seal against permeation by the agents" (Pal et al. 1993, p. 140).

3.2 PLASTIC SHEETING PERMEABILITY

Tests of the permeability of plastic sheeting (polyethylene) challenged with live chemical warfare agents were conducted at the Chemical Defense Establishment in Porton Down, England in 1970 (NATO 1983, p. 133). Agents tested included H and VX, but not GB. Four types of polyethylene of varying thickness were tested: 2.5, 4, 10 and 20 mil (0.0025, 0.004 in., 0.01 in., and 0.02 in.). The results of these tests are shown in Table 1.

Table 1: Permeability of plastic sheeting to liquid agent

	Breakthrough time (h)	
Thickness	VX	H
0.0025	3	0.3
0.004	7	0.4
0.01	30	2
0.02	48	7

Source: NATO 1983, p. 136.

The data shows that at thickness of 10 mil or greater, the plastic sheeting provided a good barrier for withstanding liquid agent challenges, offering better protection against VX than for H. Because the greatest challenge is from a liquid agent, the time to permeate the sheeting will be longer for aerosols and still longer for vapors, but the exact relationship is unknown due to a lack of test data.

NATO Civil Defense Committee 1983. *NATO Handbook on Standards and Rules for the Protection of the Civil Population Against Chemical Toxic Agents*, AC/23-D/680, 2nd rev.

Pal, T., G.Griffin, G. Miller, A. Watson, M. Doherty, and T. Vo-Dinh. 1993. "Permeation Measurements of Chemical Agent Simulants Through Protective Clothing Materials," *J. Haz. Mat.* **33**:123-141.

UNCLASSIFIED COPY NO. 8 193

~~TOP SECRET~~

ASSISTANT DIRECTOR
FOR
NATIONAL INTELLIGENCE ESTIMATES

NATIONAL INTELLIGENCE ESTIMATE

THE PROBABILITY OF SOVIET EMPLOYMENT OF BW AND CW IN THE EVENT OF ATTACKS UPON THE US

NIE-18

Published 10 January 1951

CENTRAL INTELLIGENCE AGENCY

GA AND GB NERVE GASES

1. GENERAL. GA and GB are colorless, odorless, low viscosity liquids, somewhat more volatile than kerosene. They become effective anti-personnel agents when dispersed as a vapor or invisible fog. GB is approximately 2½ times more toxic than GA.

2. QUANTITIES REQUIRED FOR EFFECTIVE EMPLOYMENT.

2.1 MILITARY ATTACK.

2.11 Approximately 5 tons of GB used in present munitions would be required to obtain a concentration for 50% lethality, in an open area of one square mile, under favorable weather conditions as described in paragraph 2.14 below. Theoretically, some 2½ times more GA would be required for comparable effectiveness. However, dissemination of GA by munitions to date does not approach this ideal and 15 to 20 times more GA than GB may be needed for 50% lethality.

2.12 The quantities of GA and GB delivered on the target in a military attack may well be sub-lethal. However, even with as little as 1/10 of the lethal quantity, effective incapacitation and demoralization can be obtained.

2.13 Inasmuch as the nerve gases are anti-personnel weapons they would be employed against population centers and military and industrial installations where the objective is primarily incapacitation of personnel as contrasted with physical destruction. However, CW may also be employed to supplement AW and high explosives.

2.14 Effective dissemination of GA and GB against the foregoing targets requires the following conditions.

2.141 Low or medium wind velocity.

2.142 Shallow layer of cool air below a warm layer.

2.143 Openings in the buildings through which outside air can penetrate, such as windows or air conditioning inlet ducts (openings can be obtained by employing high explosive munitions concurrently with CW agents).

2.15 The atmospheric conditions usually present on many cloudy days and at times when inversion is present are suitable for a gas attack. Night conditions in times of fair weather are generally more favorable for a CW attack than day conditions. Sunny, hot days in summer time with little or no wind are unsuitable and the use of toxic agent clouds at these times would be inefficient.

2.2 SABOTAGE ATTACK.

2.21 When effectively disseminated throughout a confined space of 100,000 cubic feet, about one ounce of GA or about one-half ounce of GB are sufficient to incapacitate or kill substantially all of the people in the area. The most likely method of dissemination would be by means of an aerosol bomb type container similar to those used for insecticides. These bombs operate with an auxiliary volatile liquid, which together with the weight of the container would make the weight of the dispenser about five times the weight of the agent; that is, for 100,000 cubic feet the dispenser would weigh about ¼ pound.

2.22 In the case of the Pentagon, which has 75,000,000 cubic feet of enclosed space, 50 lbs of GA or 20 lbs of GB would have to be dispersed throughout the building to cause the above results, assuming no significant extraction by the air conditioning system. This would require 50–10 pound bombs of about 0.6 gallon capacity for GA. Fewer bombs or smaller ones in the ration of 2-½ to 1 would be needed for GB.

3. Effects Produced and Protective Measures.

3.1 GA and GB produce characteristic physiological effects, such as, contraction of the pupil of the eye, twitching eyelids, tightness of the chest, difficulty in breathing, blurring of vision, twitching of muscles, headache, nausea, vomiting, salivation and diarrhea. In the case of a lethal dose, the victim loses muscular power and coordination. In addition to intensification of the foregoing effects, convulsions occur and there is involuntary defecation and urination; distressed breathing; paralysis; unconsciousness; heart slowing, dilating and eventually stopping due to heart muscle failure and asphyxia. In general, death occurs within an hour after exposure to the lethal concentration.

3.2 The physiological effects are greatest when absorbed through the respiratory system following inhalation of the vapors. However, the same effects can be produced by larger doses through mucous membranes, open wounds, and even by a small drop of the liquid touching the skin. The liquid will penetrate ordinary clothing.

3.3 Theoretically, complete protection against the nerve gases requires not only a well fitted gas mask but also special impermeable clothing. However, except in the immediate vicinity of bursts, the concentrations which probably will be encountered will be such that gas masks will provide adequate protection for all but a few of the personnel in the target area. On the other hand, at present there is no quick method of detection of GA and GB for warning and identification.

3.4 GA and GB are easily decomposed by any acid and they hydrolyze very rapidly in alkaline solutions. Effective decontamination can be carried out with alcohol solutions of sodium and potassium hydroxide, and solutions or pastes of washing soda, lime bleach, and baking soda. Even scrubbing with soap and water is effective to a degree.

3.5 Immediate injection of atropine is extremely effective in counteracting the physiological effects of these gases.

4. References.

Additional information which may be of assistance to civil defense planning will be found in the following:

4.1 Presentation to the Secretary of Defense's Ad Hoc Committee on CEBAR 27 January 1950. Submitted by Office of Chief, Chemical Corps.

4.2 Report of the Ad Hoc Committee on BW, CW, and RW (Stephenson Committee) to the Secretary of Defense, 30 June 1950.

4.3 Summary Technical Report of NDRC Division 9, Volume 1, Parts I & II and Division 10, Volume I, Part II.

4.4 Chemical and Toxicologic Data on CW Agents by E. L. Wardell and C. A. Rouiller, Information Branch, Technical Service Division, Office of the Chief, Chemical Corps, 25 May 1948.

UNITED STATES NAVY

ABC
WARFARE DEFENSE
ASHORE

TECHNICAL PUBLICATION

NAVDOCKS-TP-PL-2
REVISED
APRIL 1960

DEPARTMENT OF THE NAVY
BUREAU OF YARDS AND DOCKS
WASHINGTON 25, D. C.

TABLE 3-2

Median Lethal and Median Incapacitating Dosages for Selected War Gases

Name and symbol	Median lethal dosage ($mg\text{-}min/m^3$)	Median incapacitating dosage ($mg\text{-}min/m^3$)
Tabun (GA)	400 for resting men	300 for resting men
Sarin (GB)	100 for resting men	75 for resting men
Soman (GD)	GB, GA range	GB, GA range
Distilled mustard (HD)	600 to 1,000 by inhalation; 10,000 by skin exposure	200 by eye effect; 2,000 by skin effect
Nitrogen mustard (HN-1)	1,500 by inhalation; 20,000 by skin exposure	200 by eye effect; 9,000 by skin effect
Nitrogen mustard (HN-2)	3,000 by inhalation	Less than HN-1, but more than HN-3
Nitrogen mustard (HN-3)	1,500 by inhalation; 10,000 by skin exposure (estimated)	200 by eye effect; 2,500 by skin effect (estimated)
Mustard (H)	600 to 1,000 by inhalation; 10,000 by skin exposure	200 by eye effect; 2,000 by skin effects
Lewisite	1,200 to 1,500 by inhalation; 100,000 by skin exposure	300 by eye effect; 1,500 by skin effect
Phosgene (CG)	3,200	1,600
Cyanogen Chloride (CK)	11,000	7,000
Hydrogen Cyanide (AC)	Approximately 2,600	Approximately 2,600

The level to which the contamination must be reduced depends on the CW agent that is employed and the type of protective gear that is provided. For example, the Lct 50 respiratory dose from GB is 100 mg-min/m^3, while the Lct 50 dose through the skin of an unclothed person is 12,000 mg-min/m^3, and the Lct 50 dose through the skin of a person wearing ordinary clothing is 15,000 mg-min/m^3. Thus, if personnel can wear masks and still carry out their mission, decontamination need not be as complete as if they did not wear masks.

TABLE 4-2

RW Contamination

Building surfaces or paved areas	1 hour Radiation dose rate (r/hr)	Residual: Firehosing or street flushing
Asphaltic concrete	300 1,000 3,000	0.07 0.03 0.01
Portland cement concrete	300 1,000 3,000	0.04 0.02 0.008
Tar-and-gravel roofing	300 1,000 3,000	0.03 0.02 0.01
Composition roofing	300 1,000 3,000	0.04 0.03 0.01
Wood shingle	300 1,000 3,000	0.17 0.10 0.04
Galvanized corrugated steel	300 1,000 3,000	0.05 0.02 0.006
Smooth painted surface	300 1,000 3,000	0.04 0.01 0.004

STANFORD RESEARCH INSTITUTE

STANFORD, CALIFORNIA

June, 1953

Final Report

IMPACT OF AIR ATTACK IN WORLD WAR II:
SELECTED DATA FOR CIVIL DEFENSE PLANNING

Division II: Effects on the General Economy

Volume 1: Economic Effects - Germany

Part One

SRI Project 669

Prepared for

Federal Civil Defense Administration
Washington, D. C.

Approved:

William J. Platt

William J. Platt, Chairman
Industrial Planning Research

Weldon B. Gibson

Weldon B. Gibson, Director
Economics Research Division

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price $1.25

<u>Over-all Report (European War)</u>. 109 pp. STRATEGIC BOMBING SURVEY

This volume recounts the history of the build-up of air power, showing the great increase in 1945. The results of attack on selected major industries in Germany are also considered. The report concludes that attrition caused the downfall of economy, especially as it affected transportation and oil.

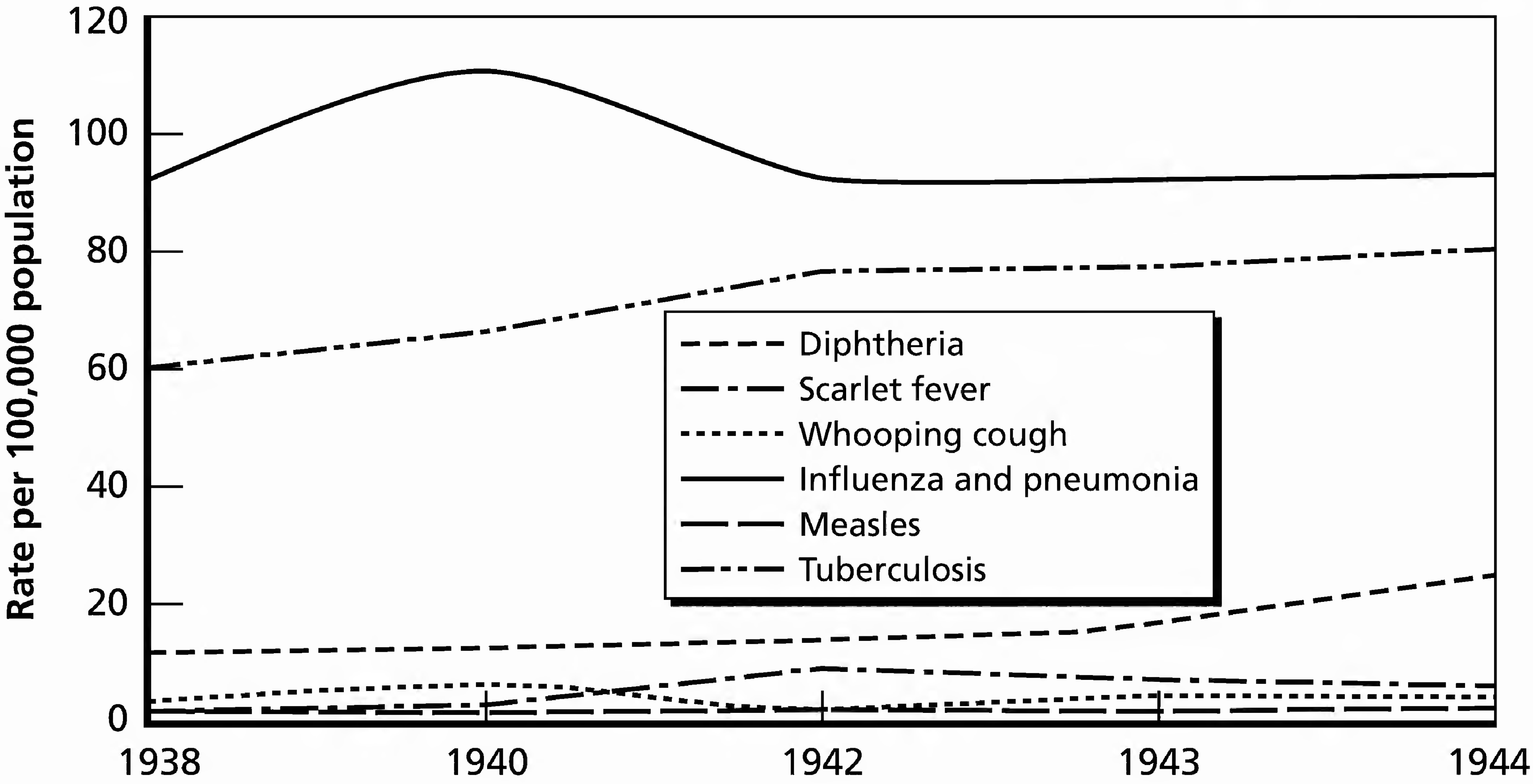
LOGISTICS TARGETTED

<u>Summary Report (European War)</u>. 18 pp. STRATEGIC BOMBING SURVEY

Germany planned a quick war; the Allies planned a long war and started a systematic attack on German industry. The British concentrated on area raids; the United States, on precision bombing. Ball bearings, aircraft, oil, steel, and transportation were attacked in order. The attack on transportation was the decisive blow that completely disorganized the German economy. Civilians withstood bombing fairly well, and the recuperation of German industry was surprising.

Mortality Rate for Several Diseases, Germany, 1938–1944

Seth G. Jones, et al., "Securing Health", RAND Corp report MG321, 2006, Fig. 2.3



SOURCE: United States Strategic Bombing Survey, *The Effect of Bombing on Health and Medical Care in Germany*, pp. 30–105.

THE UNITED STATES

STRATEGIC BOMBING SURVEY

THE EFFECTS OF STRATEGIC BOMBING ON GERMAN MORALE

VOLUME I

Morale Division

Dates Of Survey:

March-July, 1945

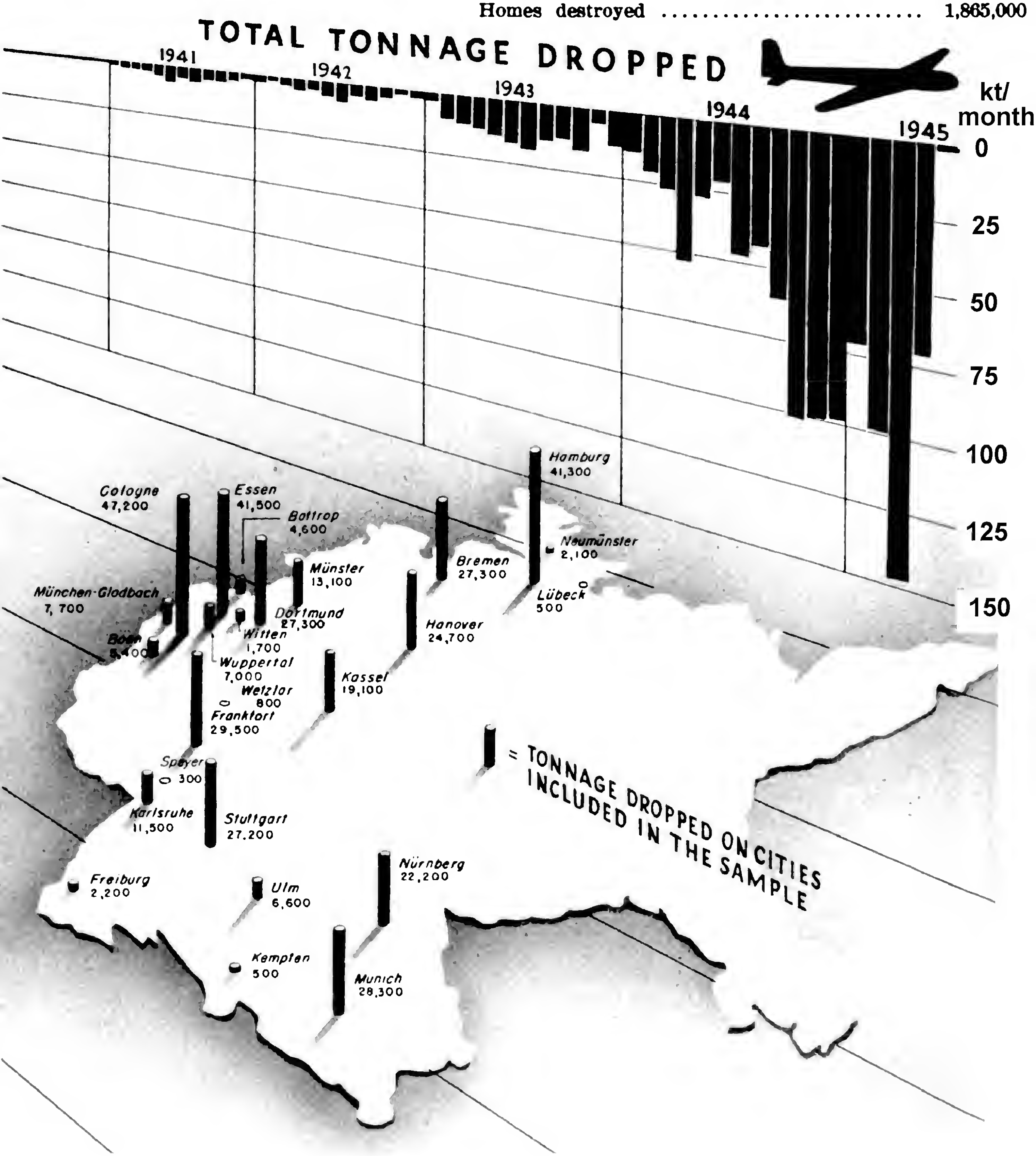
Date of Publication:

May 1947

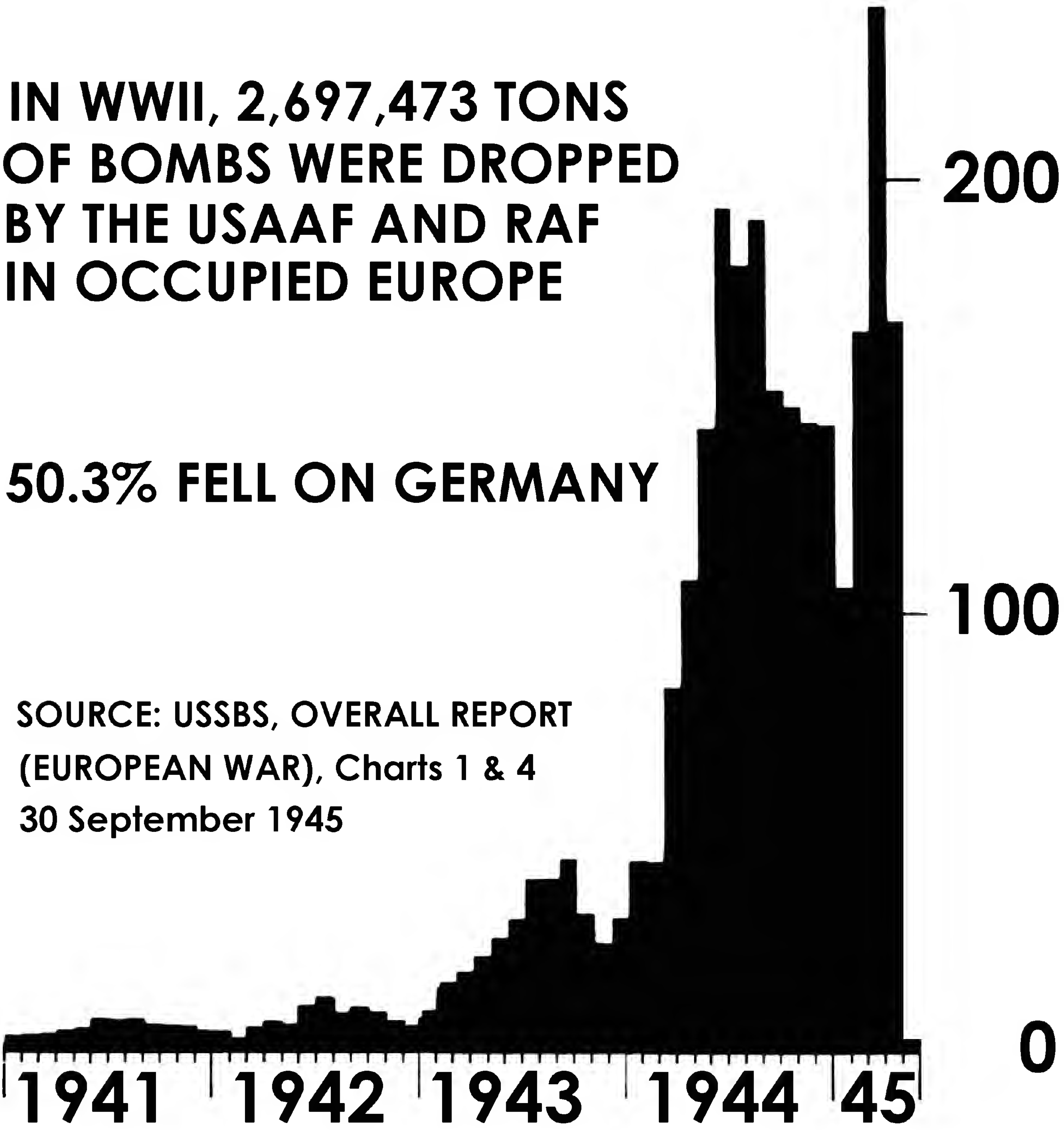
BOMBING ATTACKS ON GERMANY

TABLE 1.—*Physical effects of bombing*

Killed	305,000
Wounded	780,000
Homes destroyed	1,865,000



CONVENTIONAL KILOTONS/MONTH DROPPED IN WWII BY ALLIES



IN WWII, 2,697,473 TONS OF BOMBS WERE DROPPED BY THE USAAF AND RAF IN OCCUPIED EUROPE

50.3% FELL ON GERMANY

SOURCE: USSBS, OVERALL REPORT (EUROPEAN WAR), Charts 1 & 4
30 September 1945

THE UNITED STATES

STRATEGIC BOMBING SURVEY

THE EFFECTS OF AIR ATTACK ON JAPANESE URBAN ECONOMY

SUMMARY REPORT

Urban Areas Division

March 1947

TABLE 5.—*Damage to urban areas*

Total built-up area	square miles	[1]411
Target area	do	[1]192
Area destroyed	do	[1,2]178
Total population		21,928,000
Bombs dropped (74 percent incendiary)	tons	121,458
Buildings destroyed		2,094,374
Persons killed		252,769
Persons injured		298,650
Persons rendered homeless		8,324,000
Planned evacuations		2,100,000

[1] Operational summary, Twentieth Airforce. Refers only to 66 cities which were targets of planned urban area missions.

[2] 43 percent total built-up area for 66 cities.

The cities of Japan, like those in Germany, presented a spectacle of enormous destruction. Although the over-all total damage was somewhat greater in Germany than in Japan the extent of destruction was comparable. Only 160,800 tons of bombs were dropped on Japan's home islands as compared with 1,360,000 tons dropped within Germany's own borders. One hundred and four thousand tons of bombs were dropped on 66 Japanese cities as compared with 542,554 tons of bombs that were dropped on 61 German cities.

As in Germany, the air attacks against Japanese cities were not the cause of the enemy's defeat. The defeat of Japan was assured before the urban attacks were launched. But this defeat, before it could be translated into the terms of surrender, might have required a costly invasion of the home islands had not the effect of the air attacks, both precision and urban, on Japan's industries and people exerted sufficient pressure to bring about unconditional surrender on 15 August. The city raids contributed substantially to that pressure by their impact on the social and economic structure of Japan.

The insufficiency of Japan's war economy was the underlying cause of her defeat. Before the air attacks against the cities began, war production had been steadily declining because of the ever-increasing shortages of raw materials, skilled labor, and an ill conceived dispersal program which was initiated too late. The Survey estimated that, even without air attacks, over-all production, by August 1945, would not have exceeded 60 percent and might have been as low as 50 percent of the 1944 peak.

THE UNITED STATES

STRATEGIC BOMBING SURVEY

FINAL REPORT

Covering Air-Raid Protection and Allied Subjects in

JAPAN

Civilian Defense Division

Dates of Survey:

1 October 1945—1 December 1945

Date of Publication:

February 1947

EXHIBIT A–3.

Total tons of bombs dropped on Japan by U. S. Army Air Forces—By months

AIR FORCE

Date	Total	Incendiary
1944		
June	----------	----------
July	28	----------
Aug	183	55
Sept	5	----------
Oct	159	68
Nov	766	298
Dec	992	495
1945		
Jan	1,261	435
Feb	1,884	929
Mar	12,788	10,023
Apr	16,150	3,967
May	25,065	18,699
June	27,497	18,172
July	43,422	31,670
Aug. (15 days)	23,687	13,655
Totals	153,887	98,466

EXPERIENCE OF GERMAN AND JAPANESE AIR RAIDS

Source: AD0642790, p. 8. Basic data: Dirkwood DC-WP-1040-1, AD-827 029/0

City	Lives Lost	Percent of Population	Buildings Destroyed	Area Burned, sq mi
Tokyo	84,000	1.2	300,000	15.8 (total loss)
Hamburg	42,000	2.4	300,000	4.5 (total loss)
				12 (heavy damage)
Kassel	8,700	3.8	33,000	2.9 (total loss)
Darmstadt	8,100	7.4	22,000	1.5
Hiroshima	70,000*	28.0	68,000	4.4 (firestorm area)
Nagasaki	40,000*	17.0	21,000	0.049 (fire only)
				0.864 (fire and blast)

*Guest Korean workers, POWs, and military personnel excluded.

Nihonbashi District in Tokyo after attack of March 9, 1945, with AN-M69 incendiary bombs.

CIVIL DEFENCE

RESCUE MANUAL

LONDON
HER MAJESTY'S STATIONERY OFFICE
1952

CHAPTER XI. USE OF HEAVY MECHANICAL PLANT IN RESCUE, DEMOLITION AND CLEARANCE OPERATIONS

In the last war it was found that at major incidents the use of heavy mechanical plant was frequently necessary in support of rescue operations. Such equipment was used to help in the quick removal of debris; to lift heavy blocks of brickwork or masonry; to take the weight of collapsed floors and girders so that voids could be explored and casualties extricated; to haul off twisted steelwork and other debris and to break up sections of reinforced concrete.

In future all these tasks may be required and heavy clearance may have to be effected to enable rescue and other Civil Defence vehicles

8 March 1945 Fig. 20 **1 ton of TNT equivalent**

Using heavy mechanical plant at the Smithfield Market V.2 incident.

to approach within measurable distance of their tasks. The problem of debris will in fact be a major factor in Civil Defence operations.

Heavy mechanical plant may be required for the following purposes:

(*a*) To assist in the removal of persons injured or trapped. At this stage mainly heavy plant is needed, particularly mobile cranes with sufficient length of boom or jib to reach for long distances over the wreckage of buildings.

(*b*) To force a passage for Civil Defence vehicles and fire appliances to enable them to reach areas where major rescue and other problems exist and require urgent operational action.

(*c*) To take certain safety measures—e.g., to pull down unsafe structures.

(*d*) To clear streets and pavements to help restore communications and to afford access for the repair of damaged mains and pipes beneath the streets.

(*e*) For the final clearance of debris and the tidying of sites. This is a long term and not an operational requirement.

Urgent Rescue Operations

During rescue operations in London in the last war the machines used with great success included heavy 3½-5 ton mobile cranes, mounted on road wheels, with a 30-40 ft. jib; medium heavy 2-3½ ton mobile cranes, mounted on road wheels, with a 26 ft. jib; heavy crawler tractor bulldozers; medium crawler tractor bulldozers; mechanical shovels and compressors, three stage, mounted on road wheels.

In the case of a large or multiple incident where access was obstructed by considerable quantities of scattered debris, a bulldozer or tractor was first employed in order to clear one or more approaches by which other equipment and personnel could reach the scene of operations.

Next, all debris of manhandling size was loaded into one-yard skips and discharged by the crane into lorries, giving increased manœuvring space to the Services operating on the site.

Heavy mobile cranes were then brought up to the incident where, used under the skilled direction of the rescue party Leader, they were invaluable for removing girders and large blocks of masonry which obstructed access to casualties or persons trapped. The necessary chains and wire ropes for these operations formed part of the standard equipment of the heavy and medium-heavy mobile cranes.

The work was, of course, carried out in close co-operation with the Rescue Parties who also used various forms of light mechanical equipment, such as jacks and ratchet lifting tackle for work in confined spaces.

Compressors sometimes proved valuable for breaking up large masonry such as fallen walls, into sections of a size and weight within the handling and lifting capacity of the cranes. This method was only used when it was known that there were no casualties under the masonry.

SECRET. CABINET. Copy No. 41

C.P. 108(37).

AIR RAID PRECAUTIONS - HOUSEHOLDERS' HANDBOOK.

Memorandum by the Home Secretary.

1. I circulate herewith, for the approval of the Cabinet, the Handbook which the Air Raid Precautions Department have prepared for issue to members of the general public, setting out the information which they should have to enable them to provide such protection in their homes as may be possible.

The issue of this Handbook should be free and distribution should be made to every householder in Great Britain on a basis similar to that of the Highway Code. Additional copies would be obtainable at any time at the price of 1d. at all Post Offices.

2. The Department have been engaged for the best part of twelve months in the compilation of the text and the layout of the book. Assistance has been given by a firm of publicity agents and, in addition, a wide range of outside people has been consulted. A number of Ministers have also been good enough to give the benefit of their advice to the Air Raid Precautions Department. In fact, every step has been taken that is possible to ensure that the book, while containing the essential information which the general public require, is presented in the best form possible, having regard to its purport and its message.

The Treasury have been consulted at every stage and have seen a draft of this covering note.

3. At the request of the Treasury I wish to put before my Colleagues the question of the inclusion of advertisements. There is space on the cover for two advertisements at least, and the Treasury inform me they are satisfied that a revenue of

£5,000 net could be obtained from these two pages alone.

Care would of course be exercised in the selection of firms for the purpose; but it is thought that no objection could be taken to the inclusion of advertisements by firms of such standing as H.M.V. and Bovril, both of whom are, in fact, known to be willing to pay at the rate mentioned above for these pages. Alternatively, there is the possibility of using the space for advertisements by Government Departments such as the Post Office or by the Milk Marketing Board, to be paid for at the market rate out of their authorised grants for publicity.

4. I am disposed to recommend that, with a view to reducing the cost of the Handbook as far as possible, the principle of inserting advertisements should be approved, but that in the first place efforts should be made to use the space for advertisements of this latter kind; but that if the whole space cannot be disposed of at a fair rate in this way, offers should be accepted from commercial firms or other bodies of first class reputation.

It is estimated that the cost of production and distribution would be between £30,000 and £35,000, reducible by, say, £5,000 if advertisements are accepted.

5. Owing to the length of time which must be allowed for the printing of the enormous number of copies required (say 14 millions), it would, in any case, be impossible for the issue of the book to take place before July, and for various reasons it might be desirable to postpone its issue until after the summer holidays. If my Colleagues approve, I should be glad to have discretion as to the actual time. I would, of course, give them information of the date which I would select.

The very greatest importance is attached to the issue of this Handbook, not only because of its value in instructing the public in the simple measures which they can take for their own safety, but as a means also of awakening attention to this most

vital and important part of our National Defence Schemes. I trust that my Colleagues will agree with me that the Handbook in its present form will fulfil the purpose for which it is required.

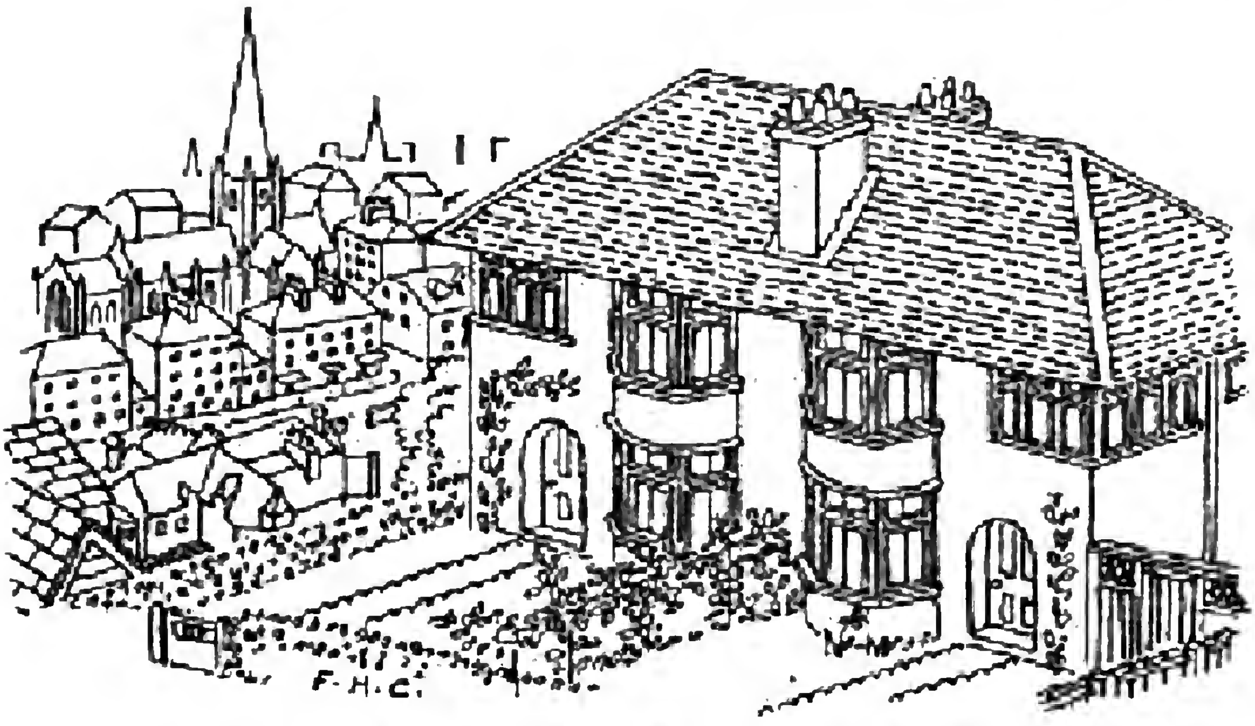
J.S.

31st March, 1937.

3rd Proof

HOME OFFICE

THE PROTECTION OF YOUR HOME AGAINST AIR RAIDS



" In the protection of your home lies the security of your country "

KEEP THIS BOOK CAREFULLY

Why this book has been sent to you

In the factory precautions are taken against unexpected accident. Cinemas and theatres are built so as to guard against the dangers of fire. The health of the community is safeguarded by precautions against the spread of epidemics. We have a great record in our country for common-sense, for the kind of forethought that reduces the ordinary risks of life to a minimum. The householder is now called upon to take precautions against a possibility we all hope will never arise. It would be folly to know of the existence of such a possibility, however remote, without acknowledging the need for precautions against it.

The Government is taking precautions against air raids and, with the help of Local Authorities everywhere, is organising measures to reduce the effects as far as possible. But the householder must play his part. This book is being sent to you in the confident belief that you will regard it as your duty to read it, to keep it by you, and to act upon it in any premises for which you are responsible; so that if your home or place of business were ever in danger of being attacked from the air, you would know what to do for your own safety and the safety of those who depend upon you.

If ever we are exposed to hostile air attack, we must look to the combination of active defence and civil air raid precautions to defeat the aims of the enemy. There is a duty on every citizen to bear his part in these civil precautions, but those who for any reason cannot take them for themselves need not be worried. They will not be overlooked.

(*Signed*)

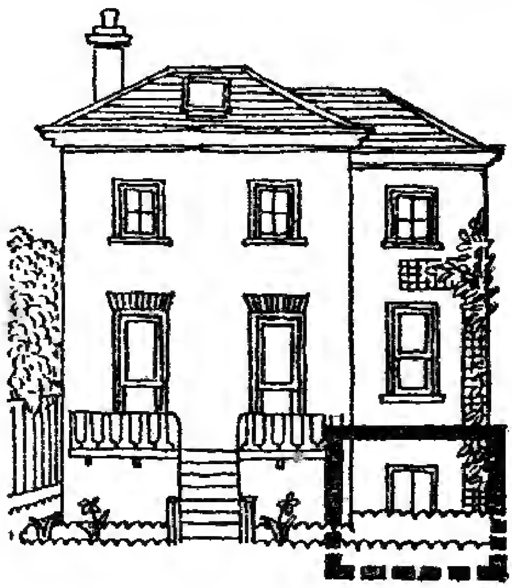
HOME OFFICE

THE PROTECTION OF YOUR HOME AGAINST AIR RAIDS

READ THIS BOOK THROUGH
THEN
KEEP IT CAREFULLY

HOW TO CHOOSE A REFUGE-ROOM

Almost any room will serve as a refuge-room if it is soundly constructed, and if it is easy to reach and to get out of. Its windows should be as few and small as possible, preferably facing a building or blank wall, or a narrow street. If a ground floor room facing a wide street or a stretch of level open ground is chosen, the windows should if possible be specially protected (see pages 30 and 31). The stronger the walls, floor, and ceiling are, the better. Brick partition walls are better than lath and plaster, a concrete ceiling is better than a wooden one. An internal passage will form a very good refuge-room if it can be closed at both ends.

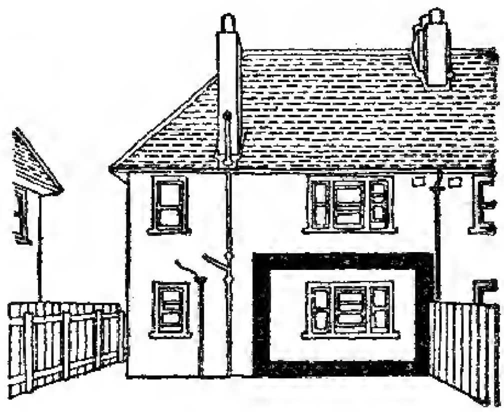


A cellar or basement is the best position for a refuge-room if it can be made reasonably gas-proof

The best floor for a refuge-room

A cellar or basement is the best place for a refuge-room if it can be made reasonably gas-proof and if there is no likelihood of its becoming flooded by a neighbouring river that may burst its banks, or by a burst water-main. If you have any doubt about the risk of flooding ask for advice from your local Council Offices.

Alternatively, any room on any floor below the top floor may be used. Top floors and attics should be avoided as they usually do not give sufficient protection overhead from small incendiary bombs. These small bombs would probably penetrate the roof but be stopped by the top floor, though they might burn through to the floor below if not quickly dealt with.

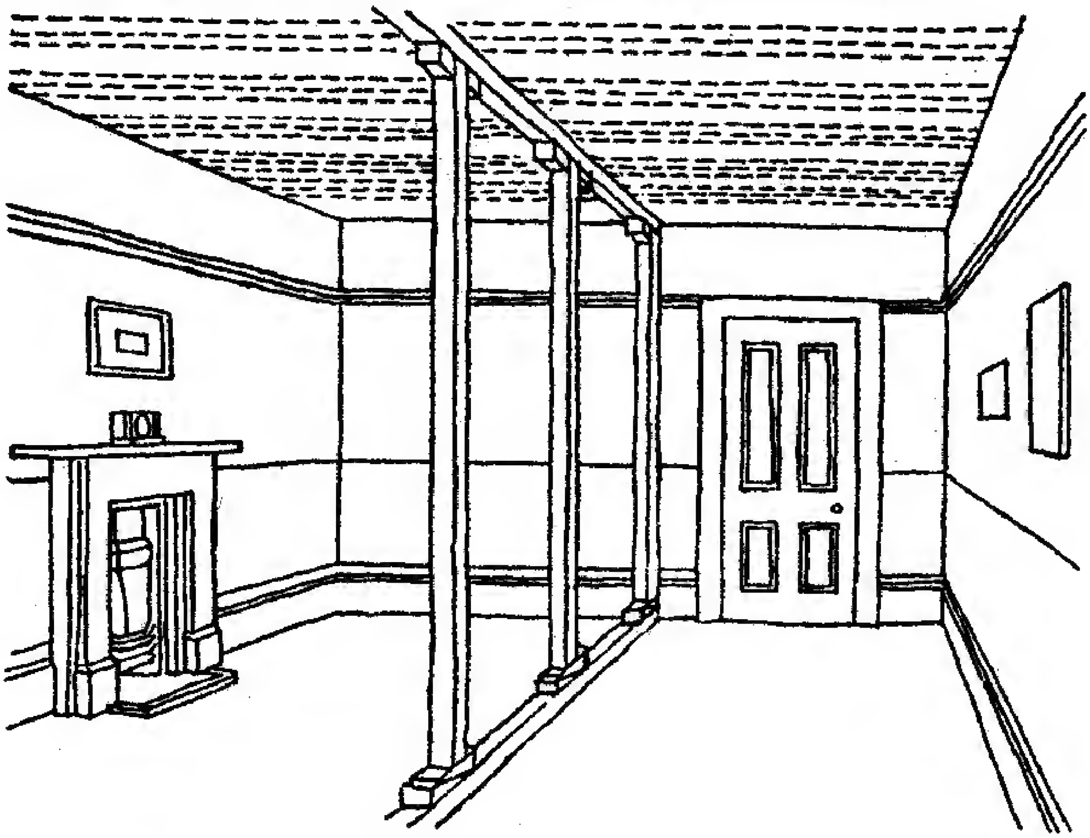


In a house with only two floors and without a cellar, choose a room on the ground floor so that you have protection overhead

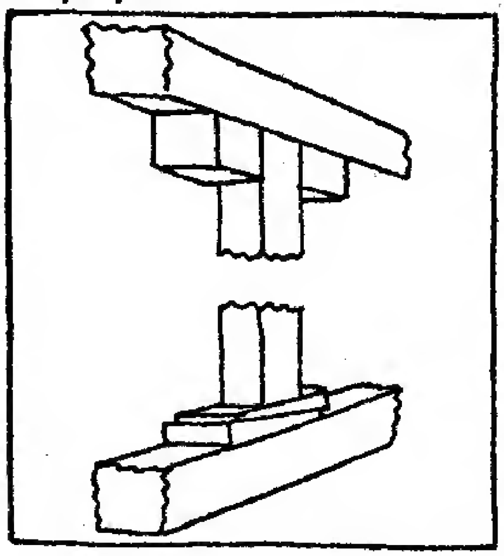
Strengthening the room

If your refuge-room is on the ground floor or in the basement, you can support the ceiling with wooden props as an additional protection. The illustration shows a way of doing this, but it would be best to take a builder's advice before setting to work. Stout posts or scaffold poles are placed upright, resting on a thick plank on the floor and supporting a stout piece of timber against the ceiling, at right angles to the ceiling joists, i.e. in the same direction as the floor boards above.

How to support a ceiling



The illustration below shows the detail of how to fix the props

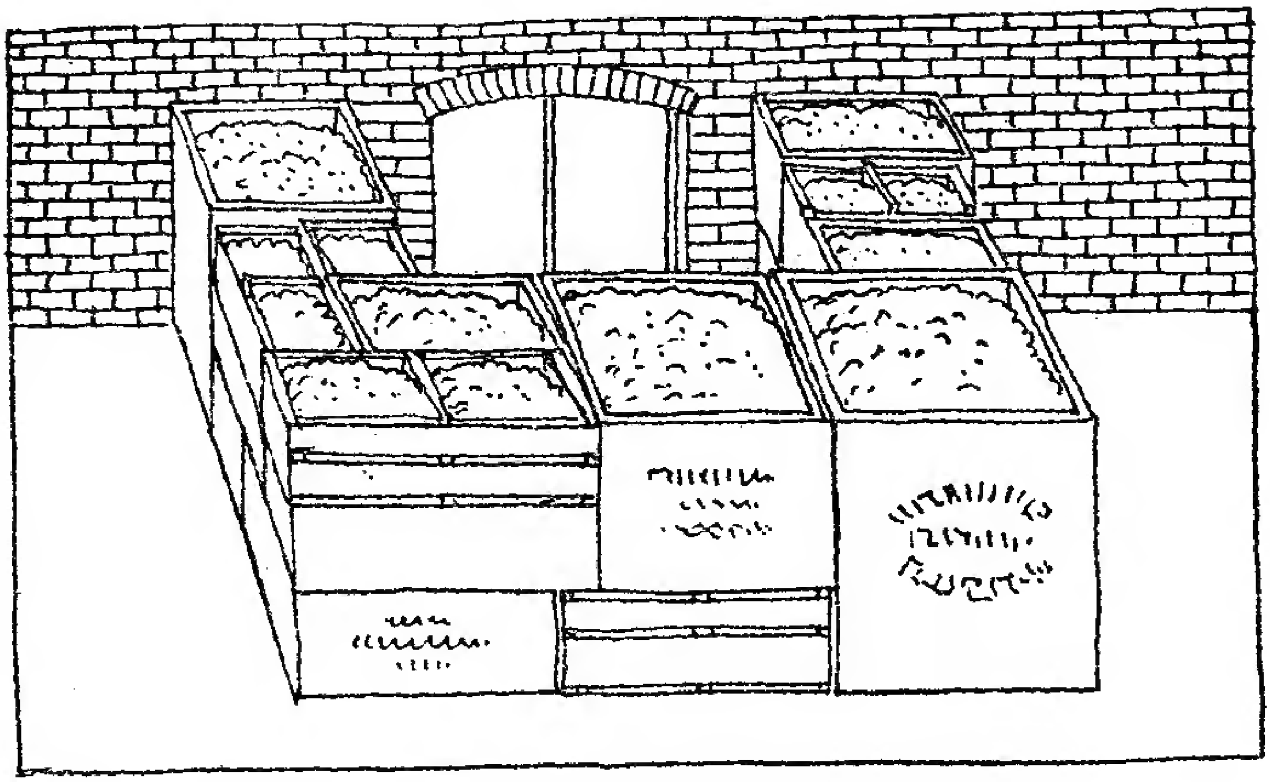


The smaller illustration shows how the posts are held in position at the top by two blocks of wood on the ceiling beam. The posts are forced tight by two wedges at the foot, driven in opposite ways. Do not drive these wedges too violently, otherwise you may lift the ceiling and damage it. If the floor of your refuge-room is solid, such as you might find in a basement, you will not need a plank across the whole floor, but only a piece of wood a foot or so long under each prop.

EXTRA PRECAUTIONS AGAINST EXPLOSIVE BOMBS

TRENCHES. Instead of having a refuge-room in your house, you can, if you have a garden, build a dug-out or a trench. A trench provides excellent protection against the effects of a bursting bomb, and is simple to construct. Full instructions will be given in another book which you will be able to buy. Your air raid wardens will also be able to advise.

SANDBAGS. Sandbags outside are the best protection if your walls are not thick enough to resist splinters. Do not rely on a wall keeping out splinters unless it is more than a foot thick. Sandbags are also the best protection for window openings. If you can completely close the window opening with a wall of sandbags you will prevent the glass being broken by the blast of an explosion, as well as keeping out splinters. But the window must still be sealed inside against gas.



A basement window protected by boxes of earth

Any bags or sacks, including paper sacks such as are used for cement, will do for sandbags. But if they are large, don't fill

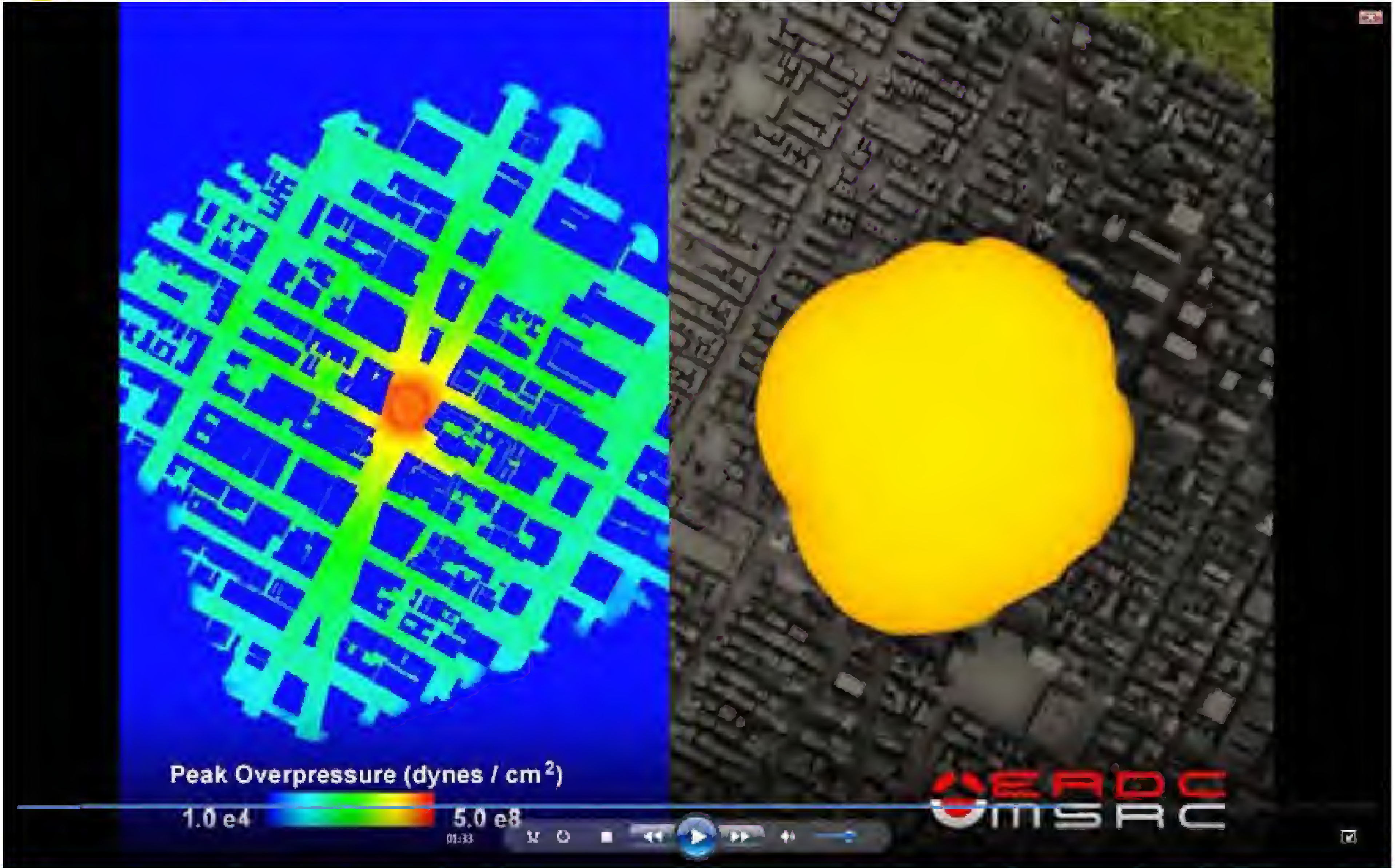
Modeling the Effects of Nuclear Weapons in an Urban Setting

Radiation Countermeasures Symposium
An AFRRI 50th Anniversary Event

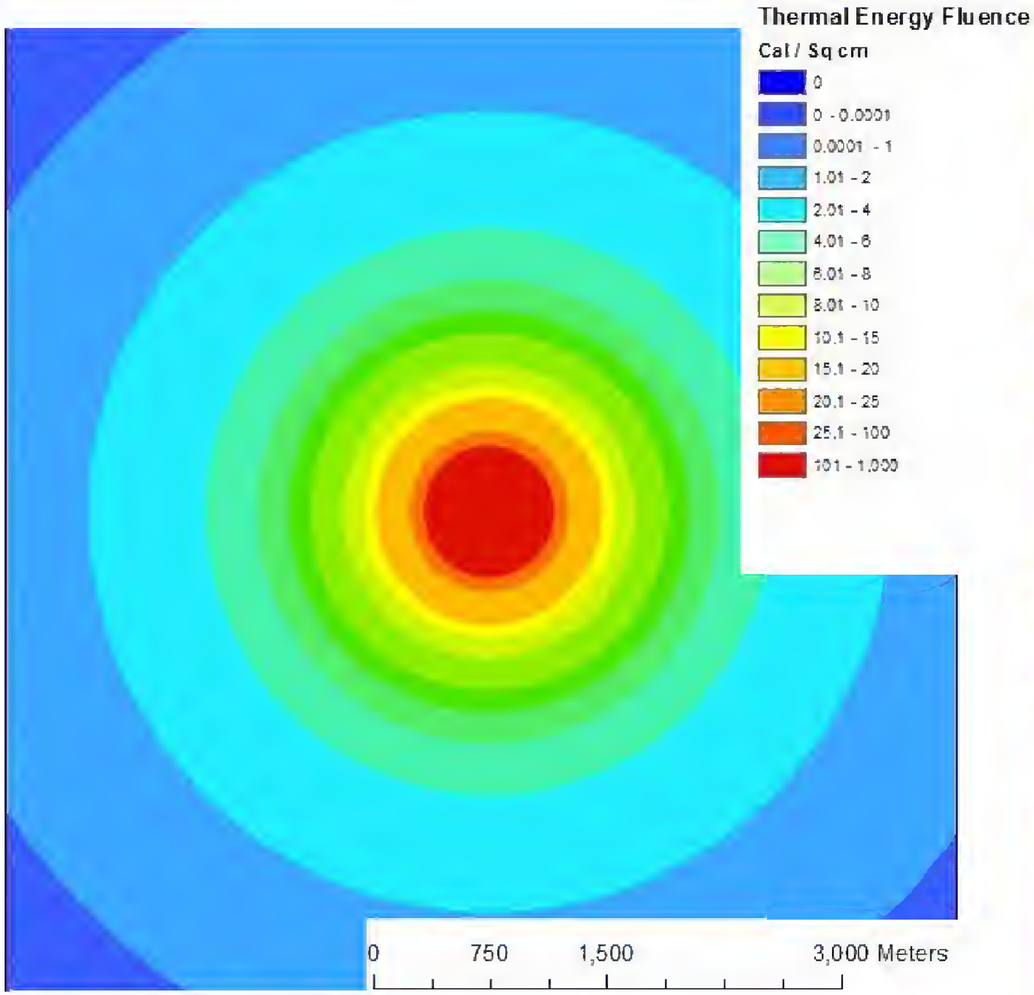
Kyle Millage, CHP, PE
Applied Research Associates, Inc.

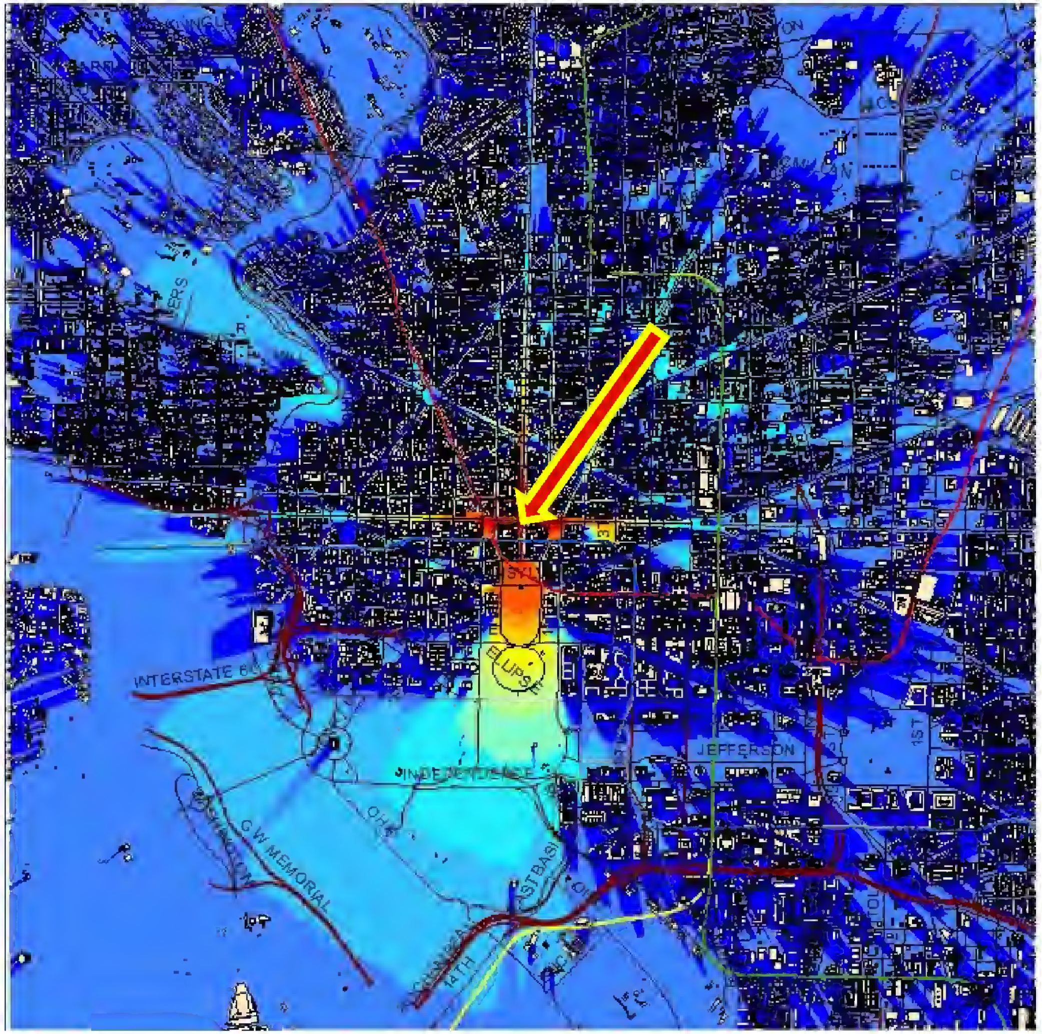
15 June 2011

Air Blast is Significantly Perturbed by Urban Terrain

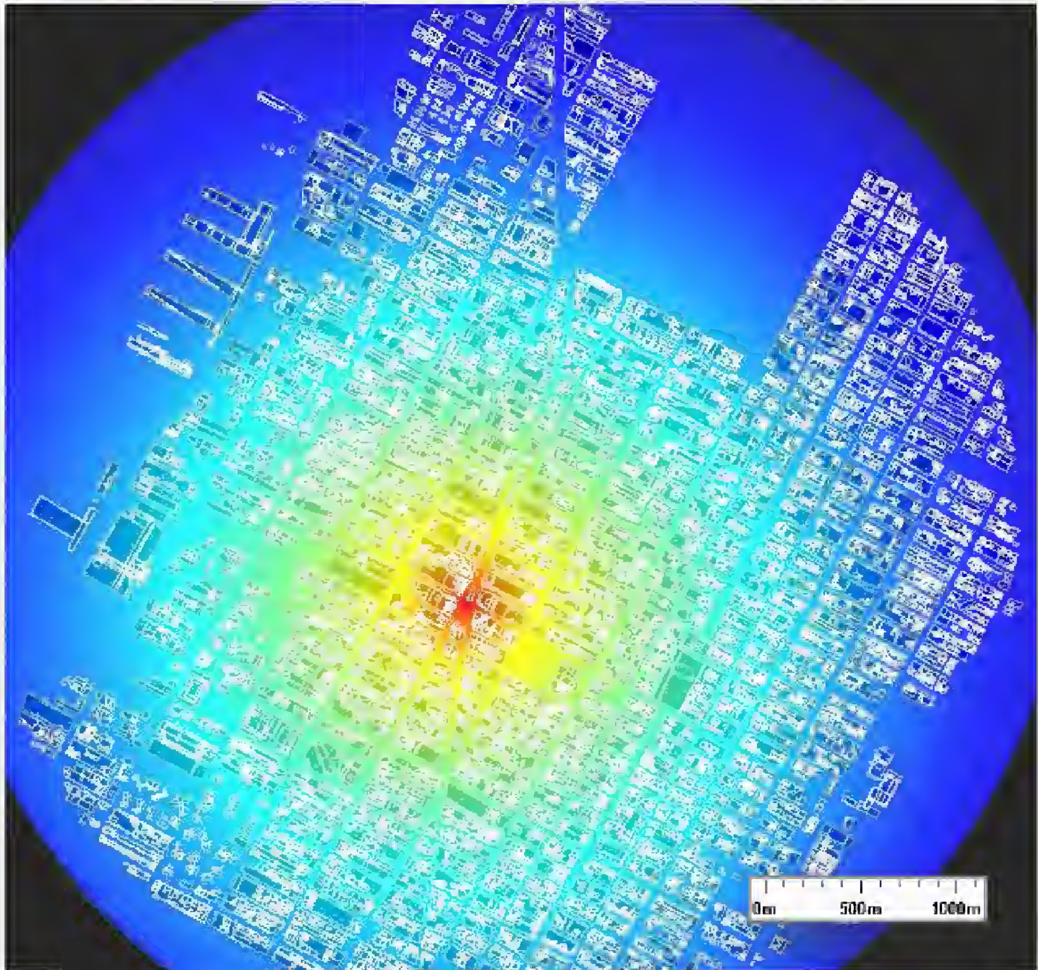


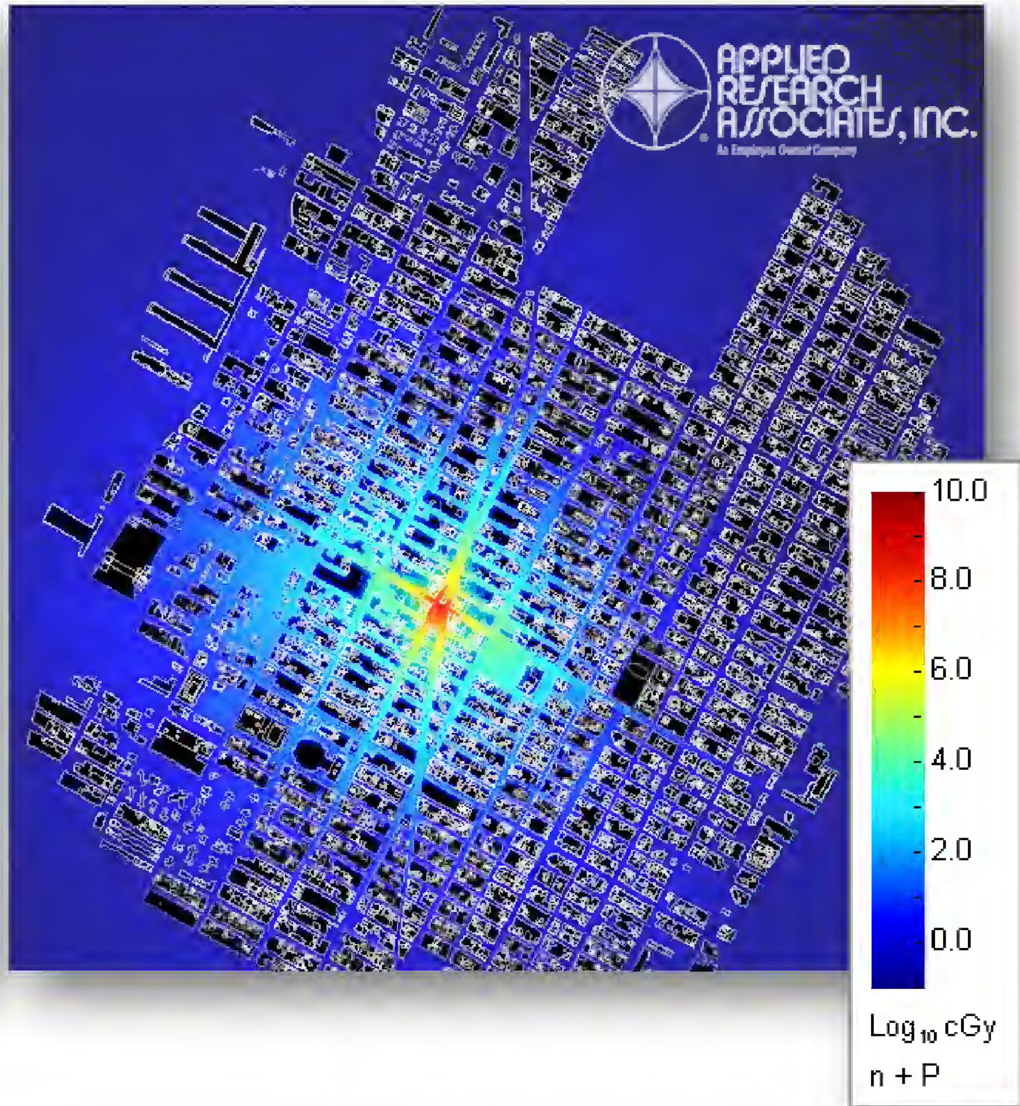
Thermal Radiation is Also Significantly Modified in an Urban Setting





Urban Terrain Significantly Attenuates Radiation Transport



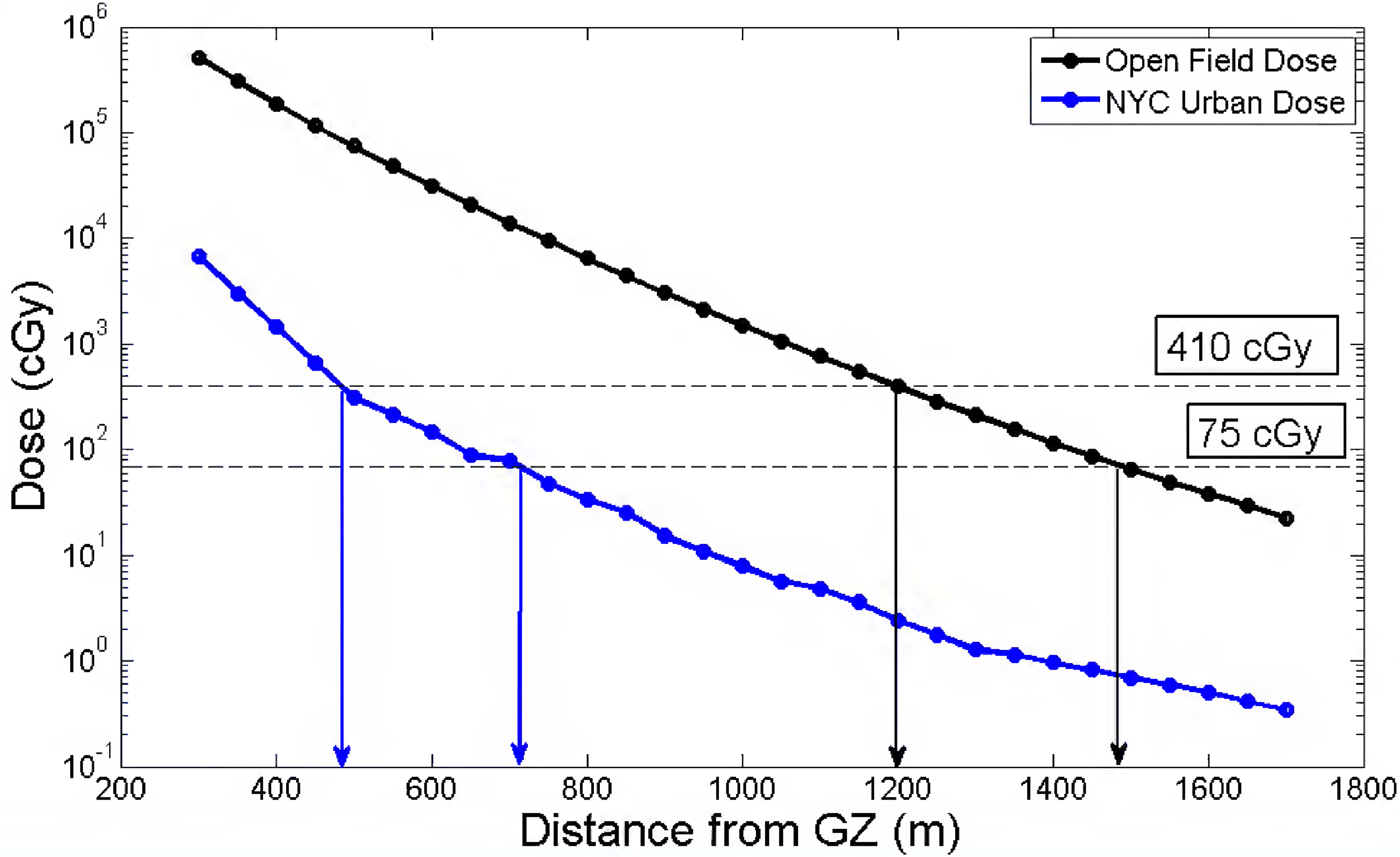


How do These Prompt Effects Alter our Casualty Expectations?

- Classic prompt circles of blast, thermal and radiation environments in an open field will significantly over-estimate the effects in an urban setting
- Fewer fatalities than you might have expected
- May suggest there will be more casualties entering the medical system than you might have expected
- Significant blunt and penetrating trauma
- Fewer thermal burns from flash
  - Burns from secondary fires unknown
- Fewer fatalities from radiation alone

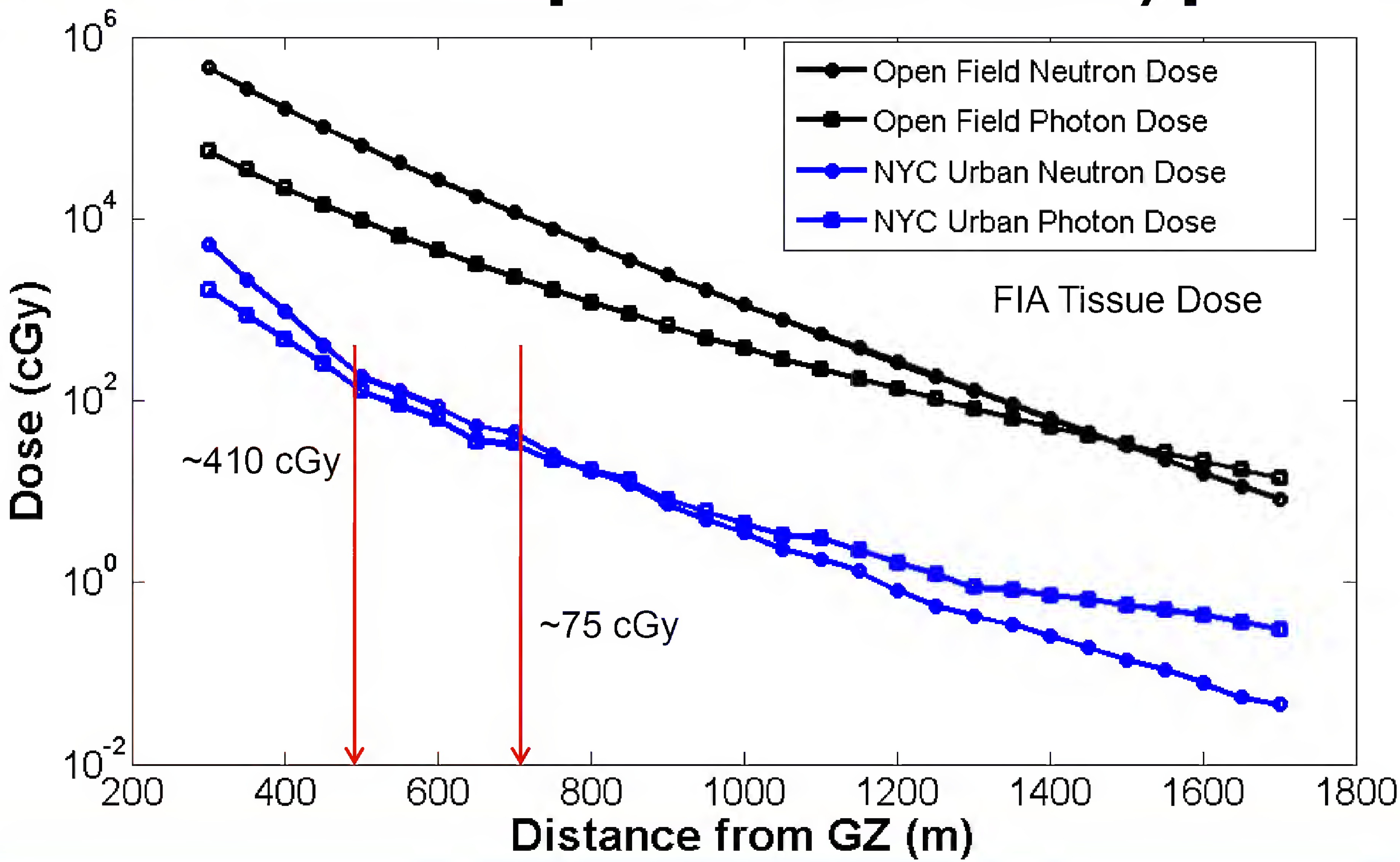
Significant numbers of sub-lethal radiation exposures, many combined with burn and trauma injury

Significant Reduction in Total Dose



Neutron and Photon Dose will Both Contribute in Survivable Dose Range

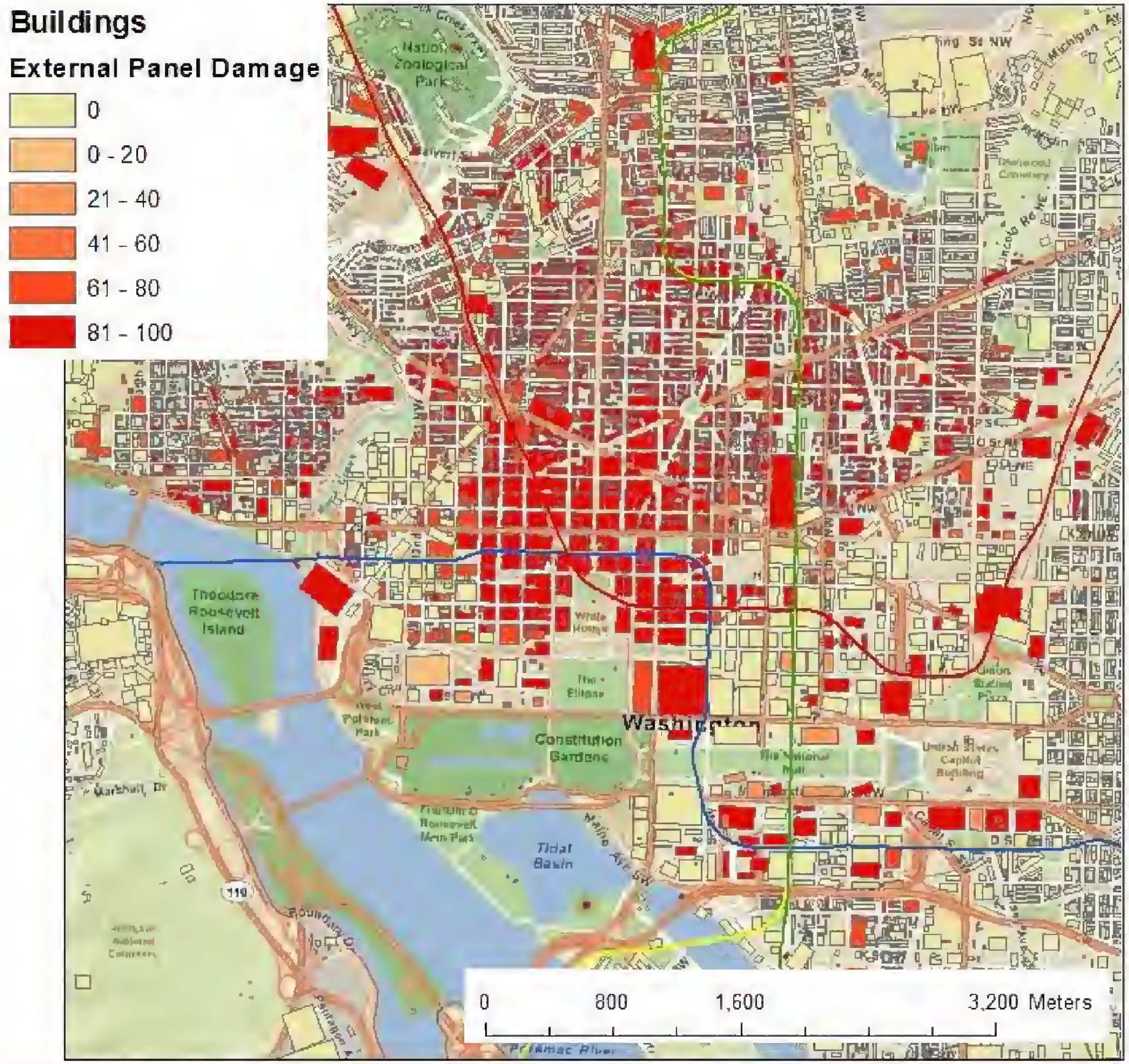
[10 kt in New York City]



Rubble Piles and Infrastructure Damage will Complicate Evacuations and Response Efforts

- Evacuation routes will be difficult due to infrastructure damage
- Risk associated with evacuation is more than just the risk associated with radiation exposure

Washington D.C. 10KT Ground Burst

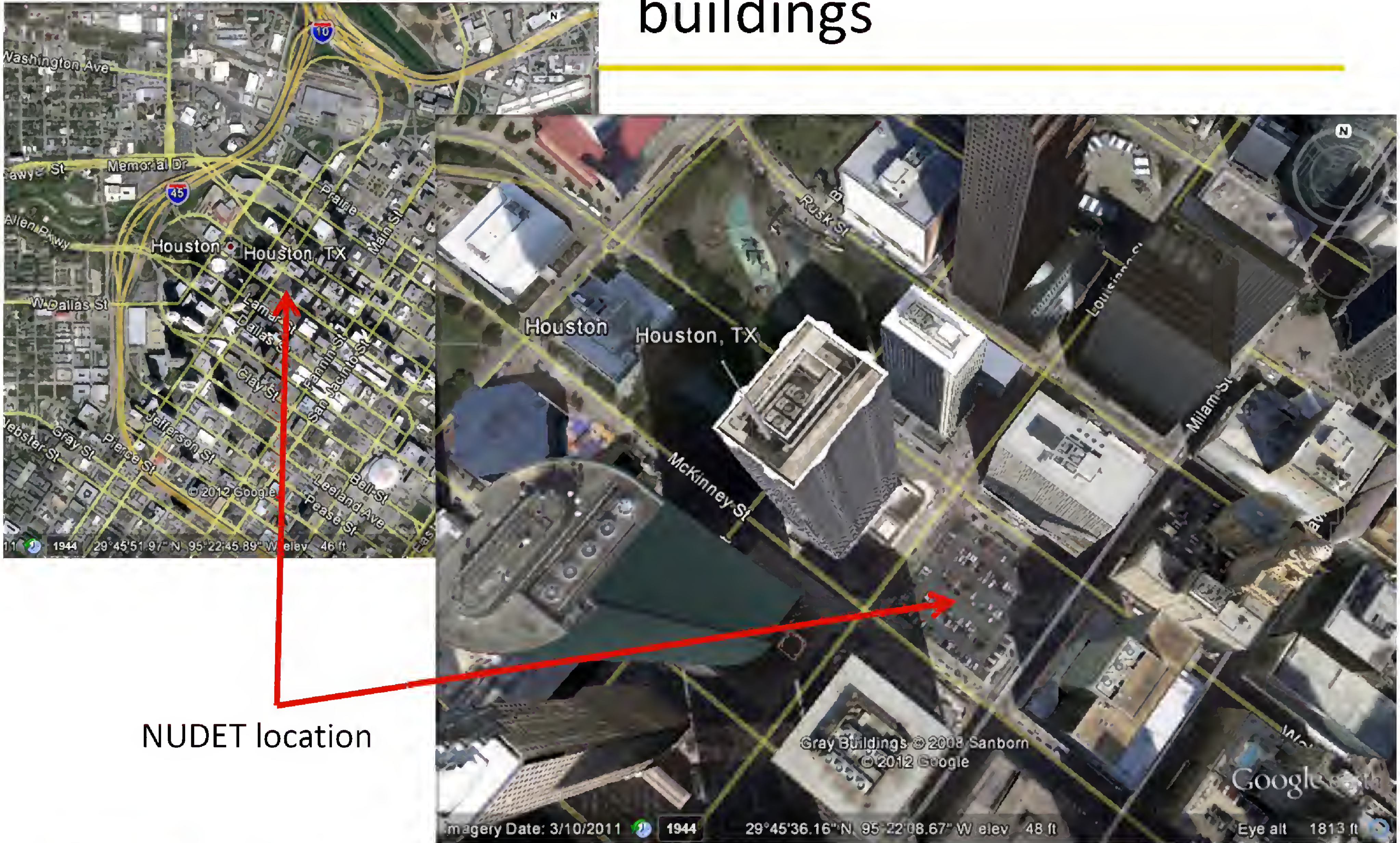


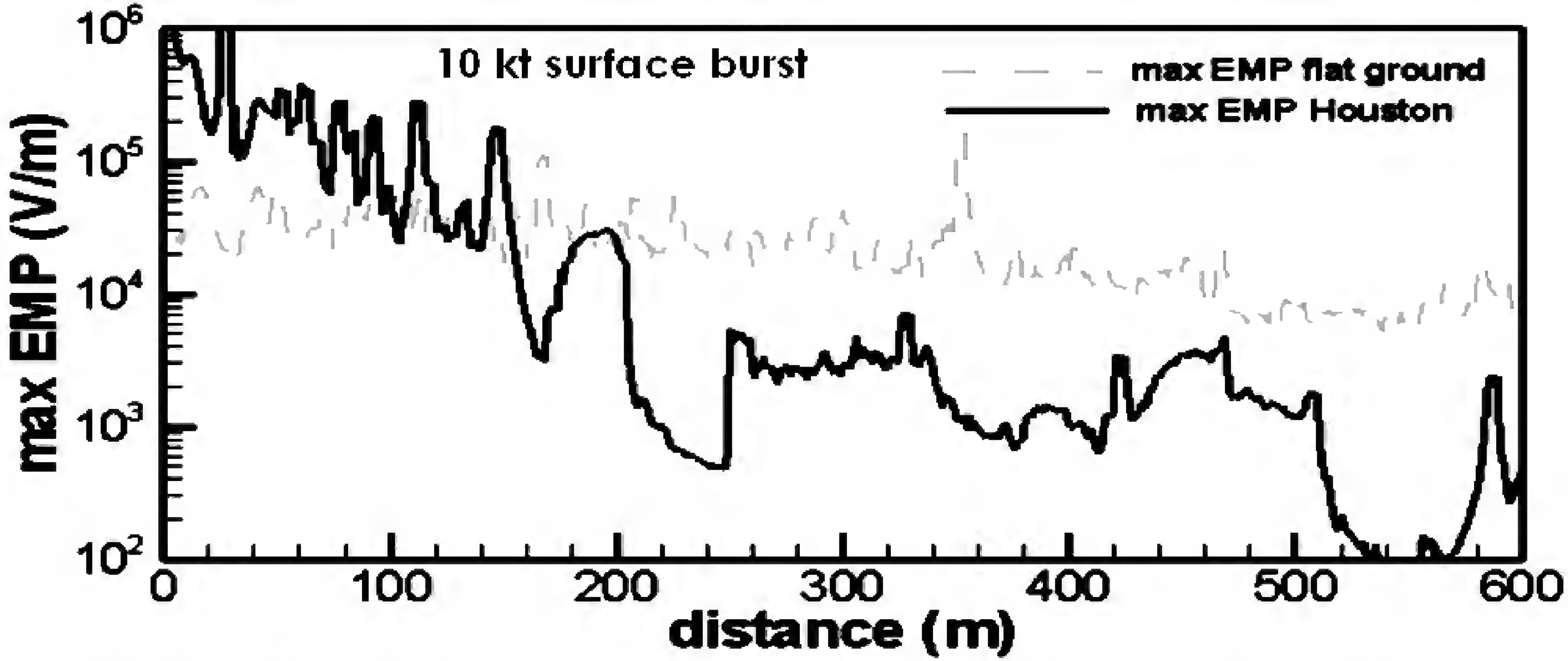
Summary

- Urban terrain significantly reduces the area impacted by nuclear weapon environments
- Survivors are likely in areas where we traditionally would have expected none
  - Both photon and neutron exposures are possible
- Many survivors will have sub-lethal radiation doses
  - Many of these will also have traumatic injuries
  - Strategies for treating combined injuries will be critical for minimizing the impact of an urban IND
- Absent other information, adequate (PF$\geq$10) shelter-in-place will likely reduce fallout exposures
- Research is ongoing to better understand the urban terrain effects

"EMP is channeled outward along street canyons."

NUDET location and surrounding buildings





Effects of buildings on maximum EMP from a generic "Fatman" type bomb in downtown Houston, Texas

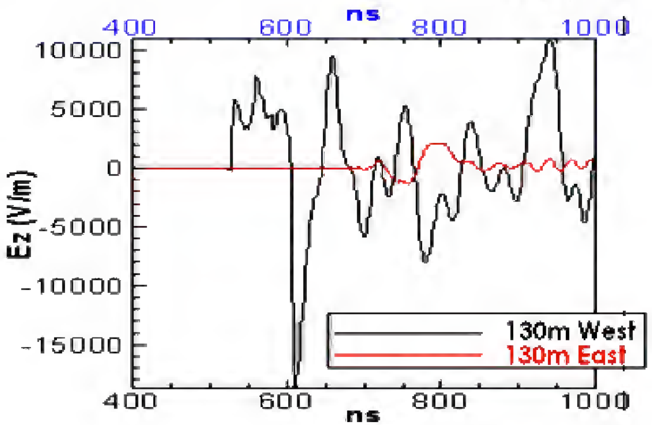
Tall buildings (1) attenuate horizontal prompt gamma rays, (2) attenuate the line-of-sight (UHF) EMP frequencies

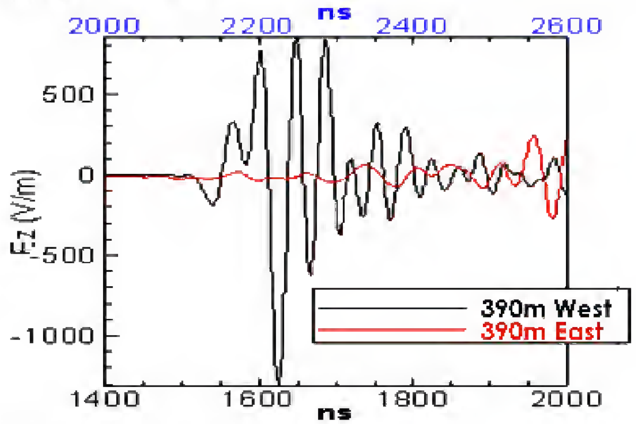
Scott Smith, Jeff Bull, Trevor Wilcox, Randy Bos, Xuan-Min Shao, Tim Goorley, Keeley Costigan

Nuclear EMP simulation for large-scale urban environments, Los Alamos LA-UR-12-24078, August 2012

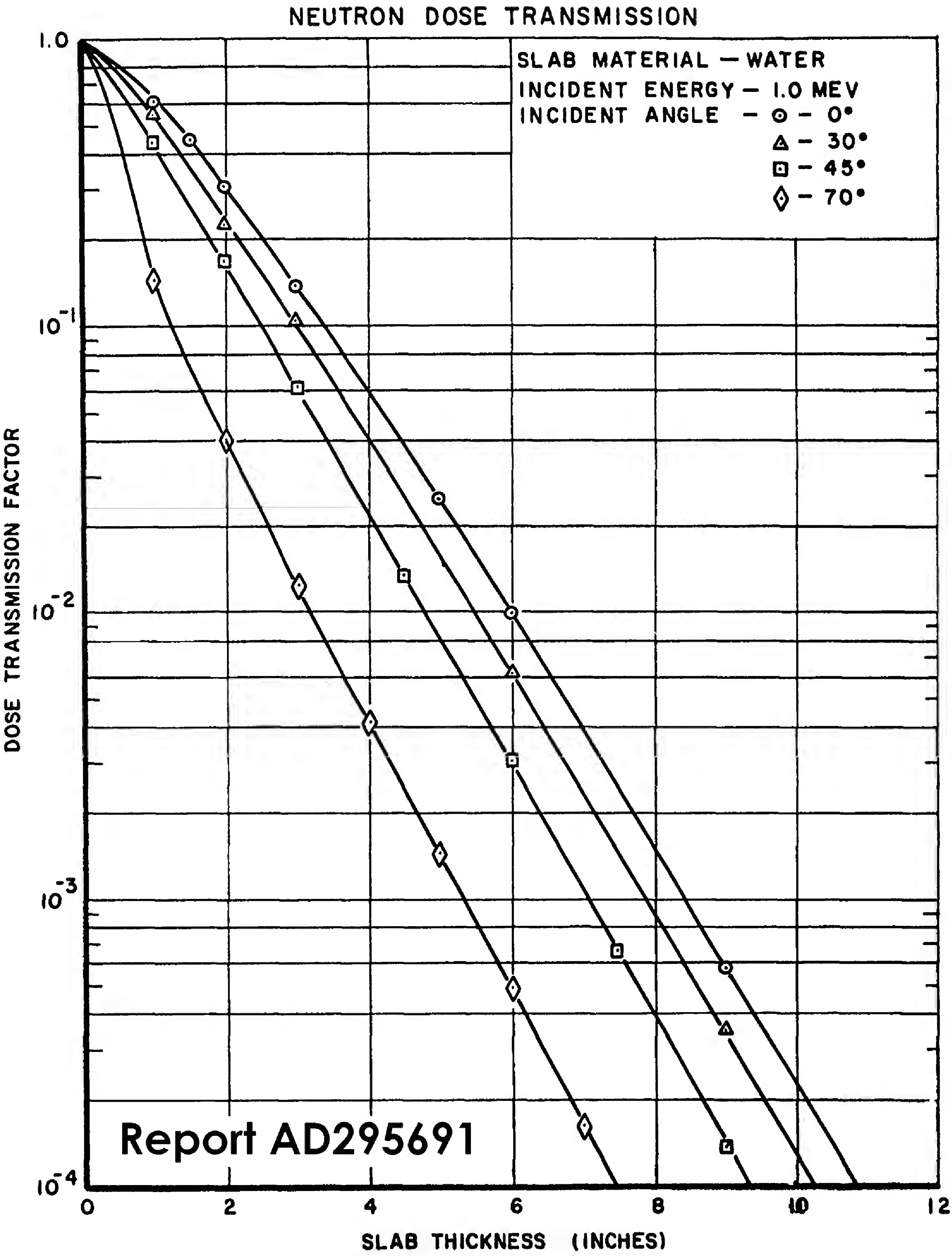
10 kt surface burst

Vertical component of EMP

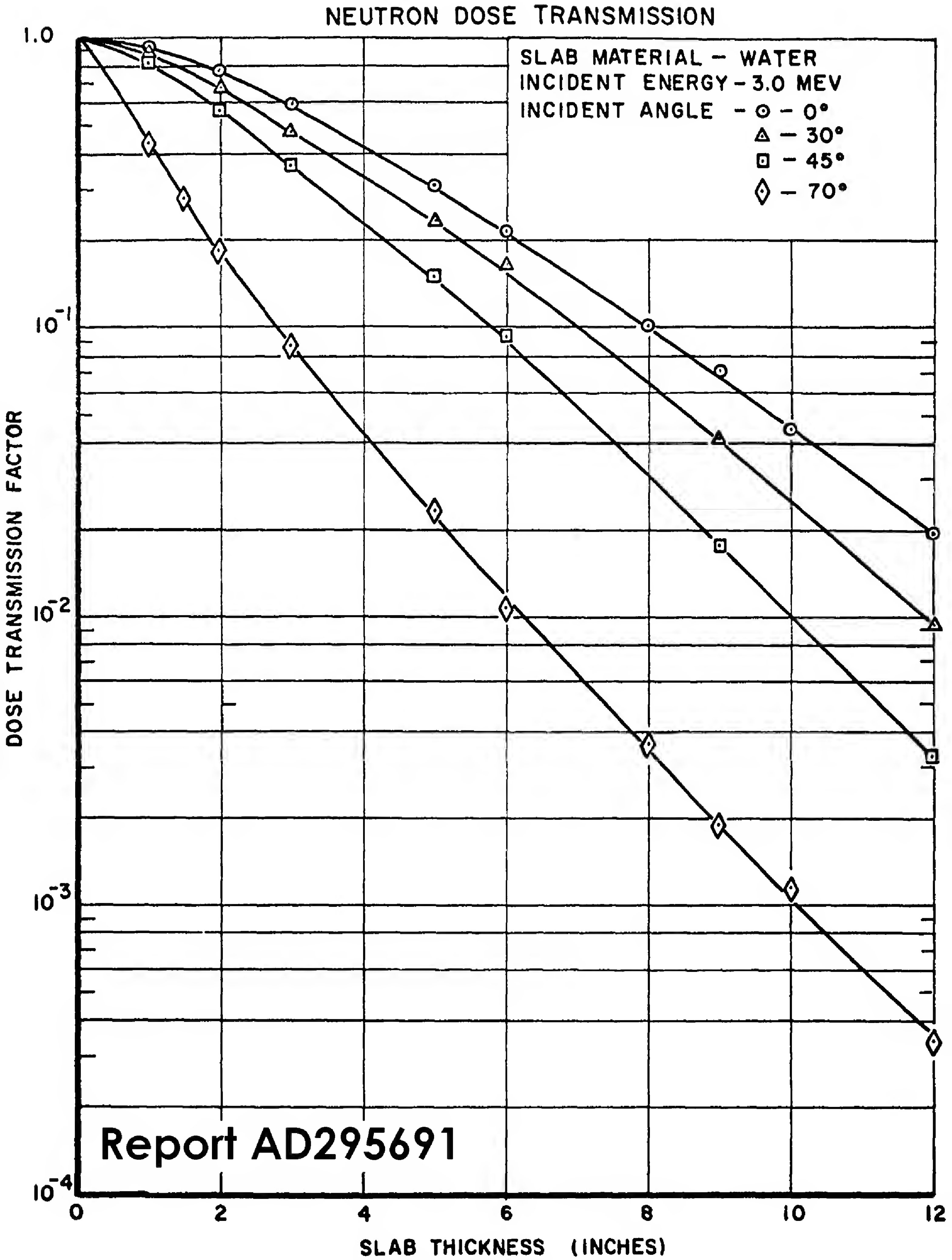




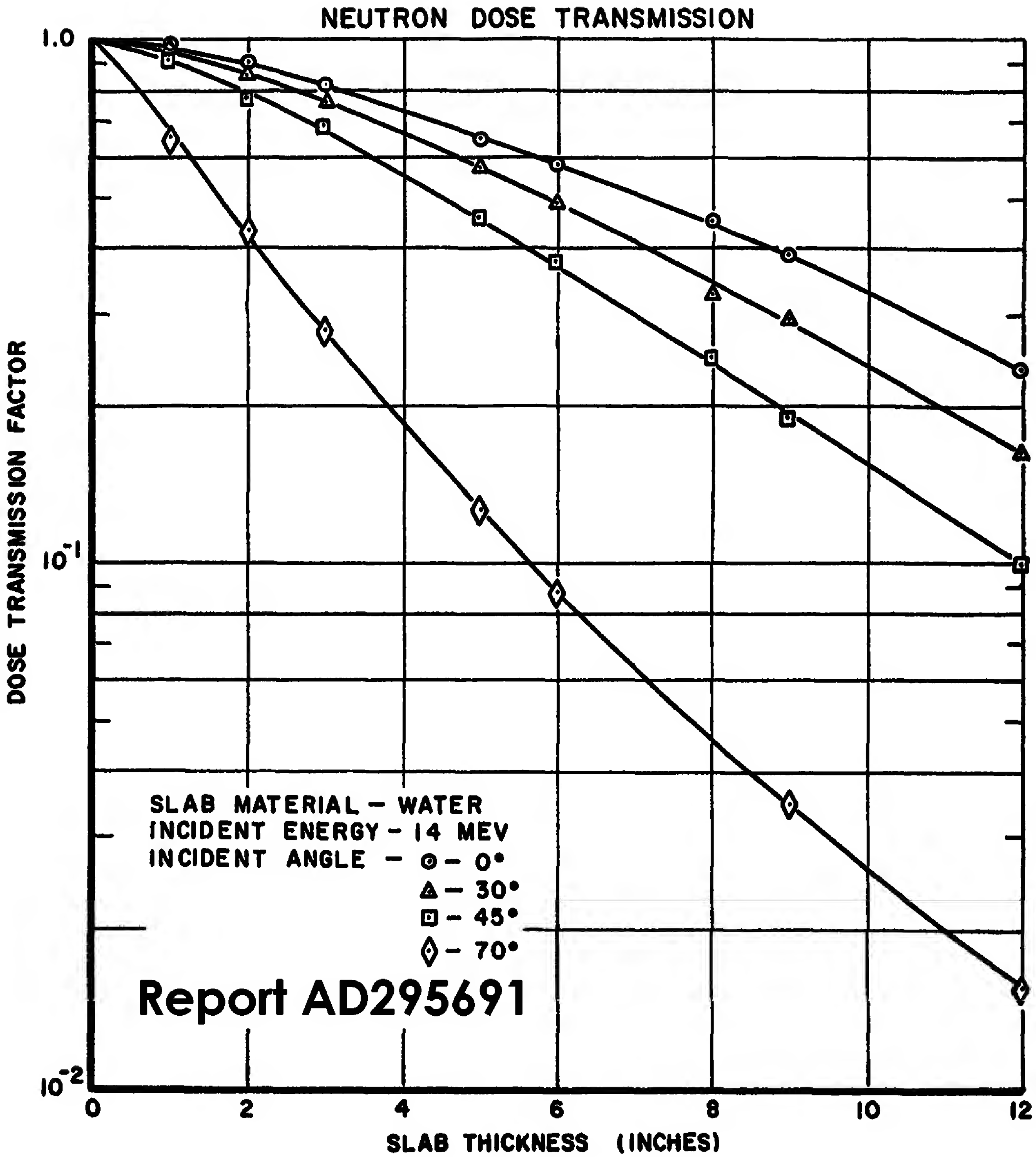
William S. Smith, et al., Nuclear EMP simulation for large-scale urban environments, Los Alamos, LA-UR-12-20227, 2012



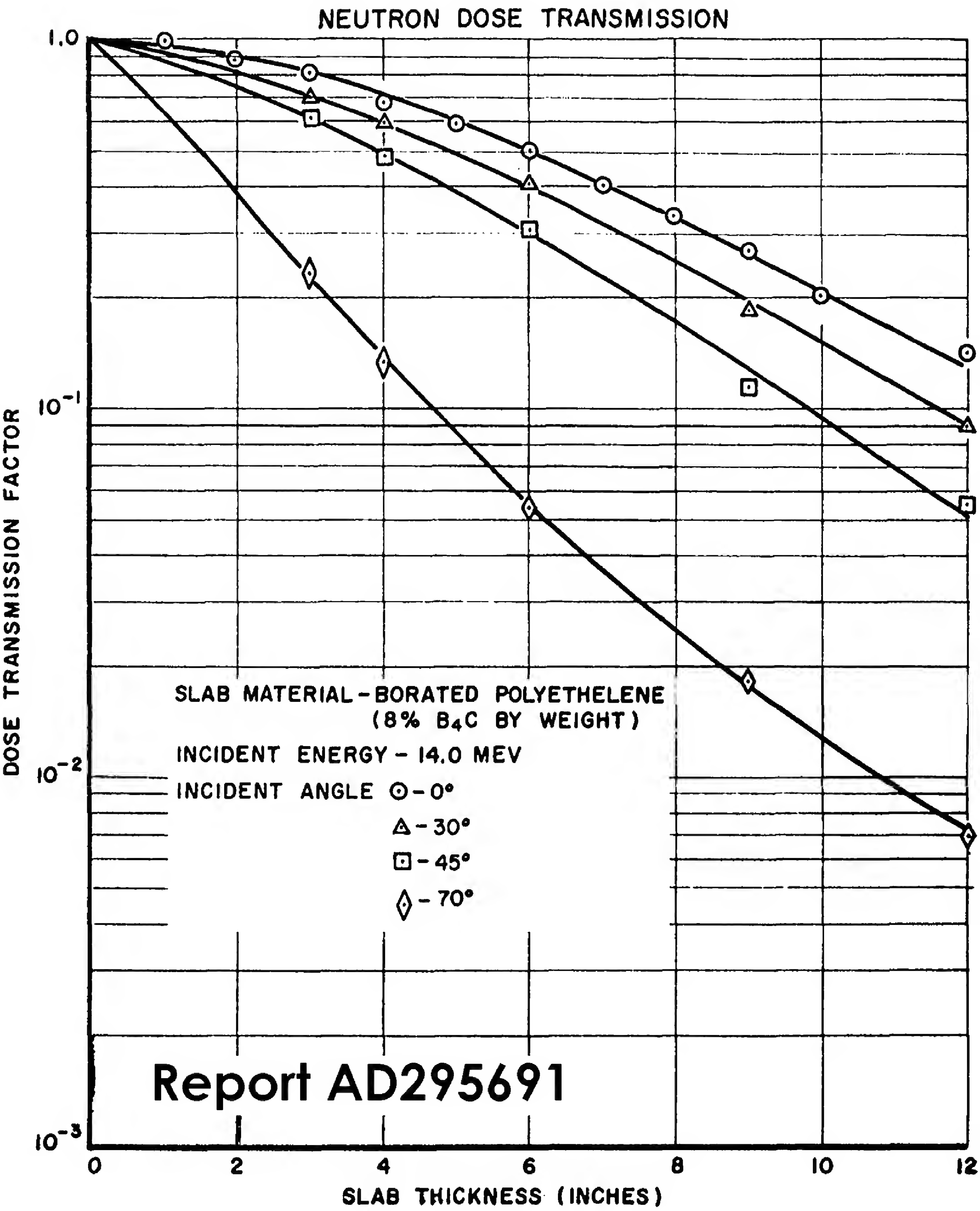
NEUTRON DOSE TRANSMISSION
SLAB MATERIAL — WATER
INCIDENT ENERGY — 1.0 MEV
INCIDENT ANGLE — ⊙ — 0°
△ — 30°
⊡ — 45°
◊ — 70°
DOSE TRANSMISSION FACTOR
1.0
10-1
10-2
10-3
10-4
0
2
4
6
8
10
12
SLAB THICKNESS (INCHES)
Report AD295691



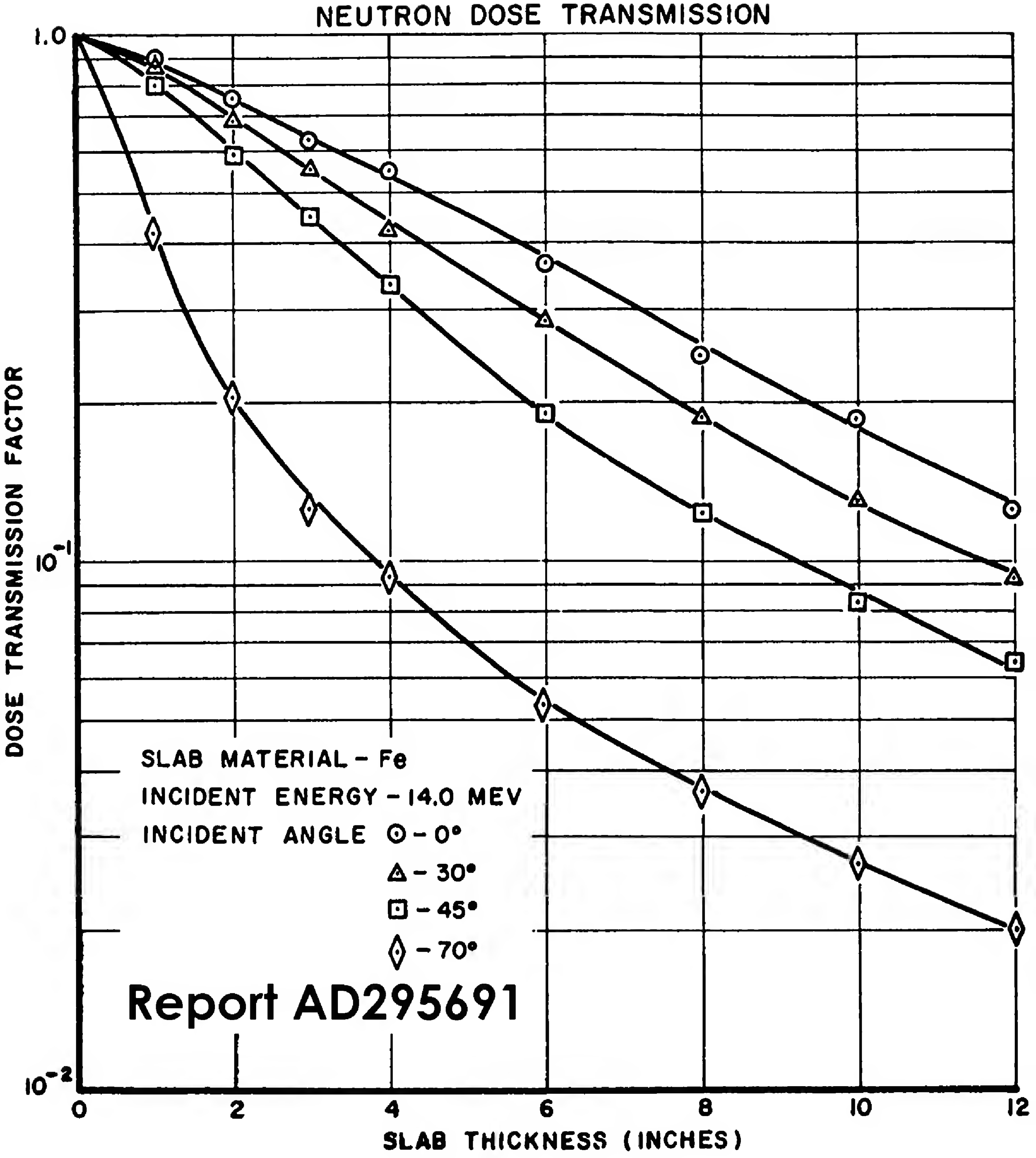
Report AD295691



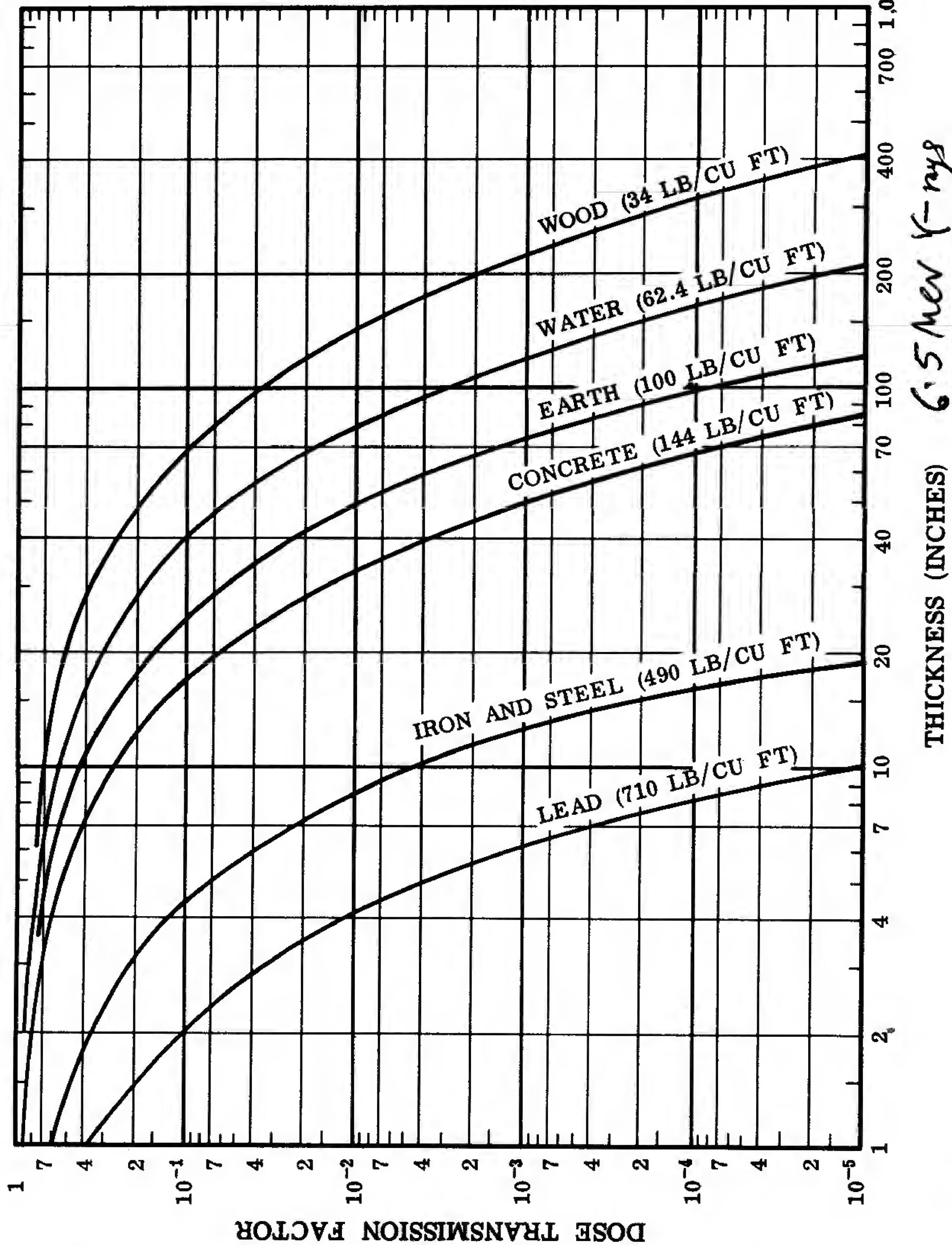
Report AD295691



Report AD295691


NEUTRON DOSE TRANSMISSION
1.0
10^{-1}
10^{-2}
DOSE TRANSMISSION FACTOR
0
2
4
6
8
10
12
SLAB THICKNESS (INCHES)
SLAB MATERIAL - Fe
INCIDENT ENERGY - 14.0 MEV
INCIDENT ANGLE ⊙ - 0°
△ - 30°
⊡ - 45°
◊ - 70°
Report AD295691

S. Glasstone, Effects of Nuclear Weapons, 1964



6.5 MeV γ-rays

Figure 8.38. Dose transmission factors for initial gamma radiations of various materials as function of thic

PAGE 401 STATES EFFECTIVE ENERGY OF GAMMA RAYS IS 6.5 MeV
(NEUTRON CAPTURE IN NITROGEN PRODUCES THESE PENETRATING GAMMA RAYS)

ORNL-TM-3396

NUCLEAR WEAPONS FREE-FIELD ENVIRONMENT RECOMMENDED FOR INITIAL RADIATION SHIELDING CALCULATIONS

J. A. Auxier, Z. G. Burson, R. L. French,
F. F. Haywood, L. G. Mooney, and E. A. Straker

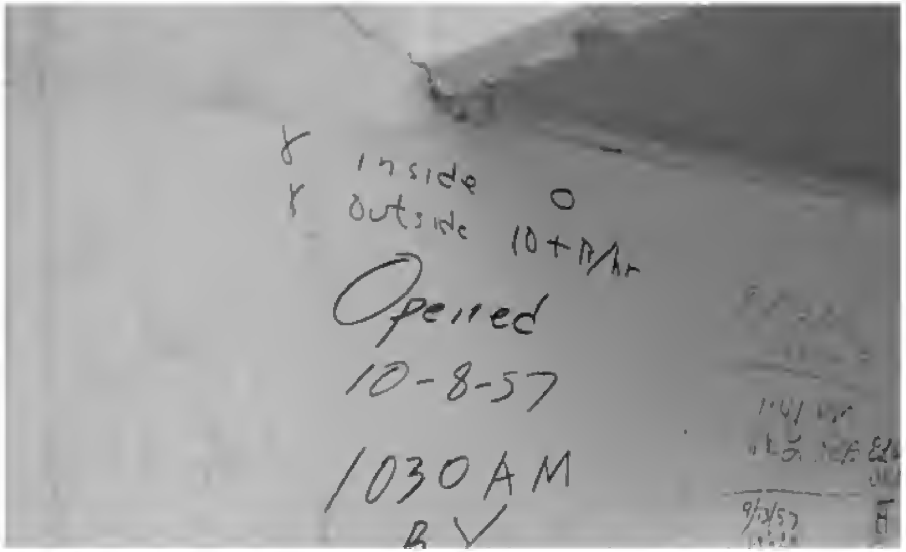
Table 8. Fission-Product Gamma Ray Exposure During the First 60 Seconds from a Typical TN Weapon at a 100-M Burst Height

Slant Range (m)	Shock Arrival (sec)	Percent Before Shock	Percent After Shock
	100 KT		
538	0.3678	13.8	86.2
740	0.8187	20.4	79.6
1030	1.822	36.2	63.8
1446	4.055	63.1	36.9
2097	11.02	95.7	4.3
	300 KT		
771	0.5488	13.7	86.3
1060	1.221	20.5	79.5
1472	2.718	38.6	61.4
2065	6.049	69.8	30.2
2995	16.44	98.8	1.2
	1 MT		
1146	0.8187	11.1	88.9
1576	1.822	18.3	81.7
2190	4.055	38.2	61.8
3075	9.024	75.3	24.7
4458	24.53	99.8	0.2

Ground Zero 29 kt APPLE-2 on 500 ft tower May 5, 1955
Tower legs are blown down, not vaporized or even melted

APPLE-2 - Robert L. Corsbie (Director), left and Fred Wilson (Assistant Director)

Shelter at ground zero, directly under 11 kt Fitzeau nuclear explosion (500 ft tower)



Test fired on 14 September 1957. Shelter was re-entered on 8 October 1957 when outdoor (ground zero) dose rate was down to about 10 R/hr. No fallout entered the concrete shelter, which was protected by a steel dome hatch (above left). Shelter had 5 feet of earth cover, and was depressed 2 feet into the ground by the shock wave. (W. G. Johnson, A Historical Evaluation of the T-3b Fizeau Bunker.)

THE EFFECTS OF THE ATOMIC BOMBS AT HIROSHIMA AND NAGASAKI

REPORT OF THE BRITISH MISSION TO JAPAN

PUBLISHED
FOR THE HOME OFFICE AND THE AIR MINISTRY BY
HIS MAJESTY'S STATIONERY OFFICE
LONDON
1946

40. The provision of air raid shelters throughout Japan was much below European standards. Those along the verges of the wider streets in Hiroshima were comparatively well constructed : they were semi-sunk, about 20 ft. long, had wooden frames, and 1 ft. 6 ins. to 2 ft. of earth cover. One is shown in photograph 17. Exploding so high above them, the bomb damaged none of these shelters.

41. In Nagasaki there were no communal shelters except small caves dug in the hillsides. Here most householders had made their own backyard shelters, usually slit trenches or bolt holes covered with a foot or so of earth carried on rough poles and bamboos. These crude shelters, one of which is shown in photograph 18, nevertheless had considerable mass and flexibility, qualities which are valuable in giving protection from blast. Most of these shelters had their roofs forced in immediately below the explosion ; but the proportion so damaged had fallen to 50 per cent. at 300 yards from the centre of damage, and to zero at about $\frac{1}{2}$ mile.

42. These observations show that the standard British shelters would have performed well against a bomb of the same power exploded at such a height. Anderson shelters, properly erected and covered, would have given protection. Brick or concrete surface shelters with adequate reinforcement would have remained safe from collapse. The Morrison shelter is designed only to protect its occupants from the debris load of a house, and this it would have done. Deep shelters such as the refuge provided by the London Underground would have given complete protection.

Photo No. 17. HIROSHIMA. Typical, part below ground, earth-covered, timber framed shelter 300 yds. from the centre of damage, which is to the right. In common with similar but fully sunk shelters, none appeared to have been structurally damaged by the blast. Exposed woodwork was liable to " flashburn." Internal blast probably threw the occupants about, and gamma rays may have caused casualties.

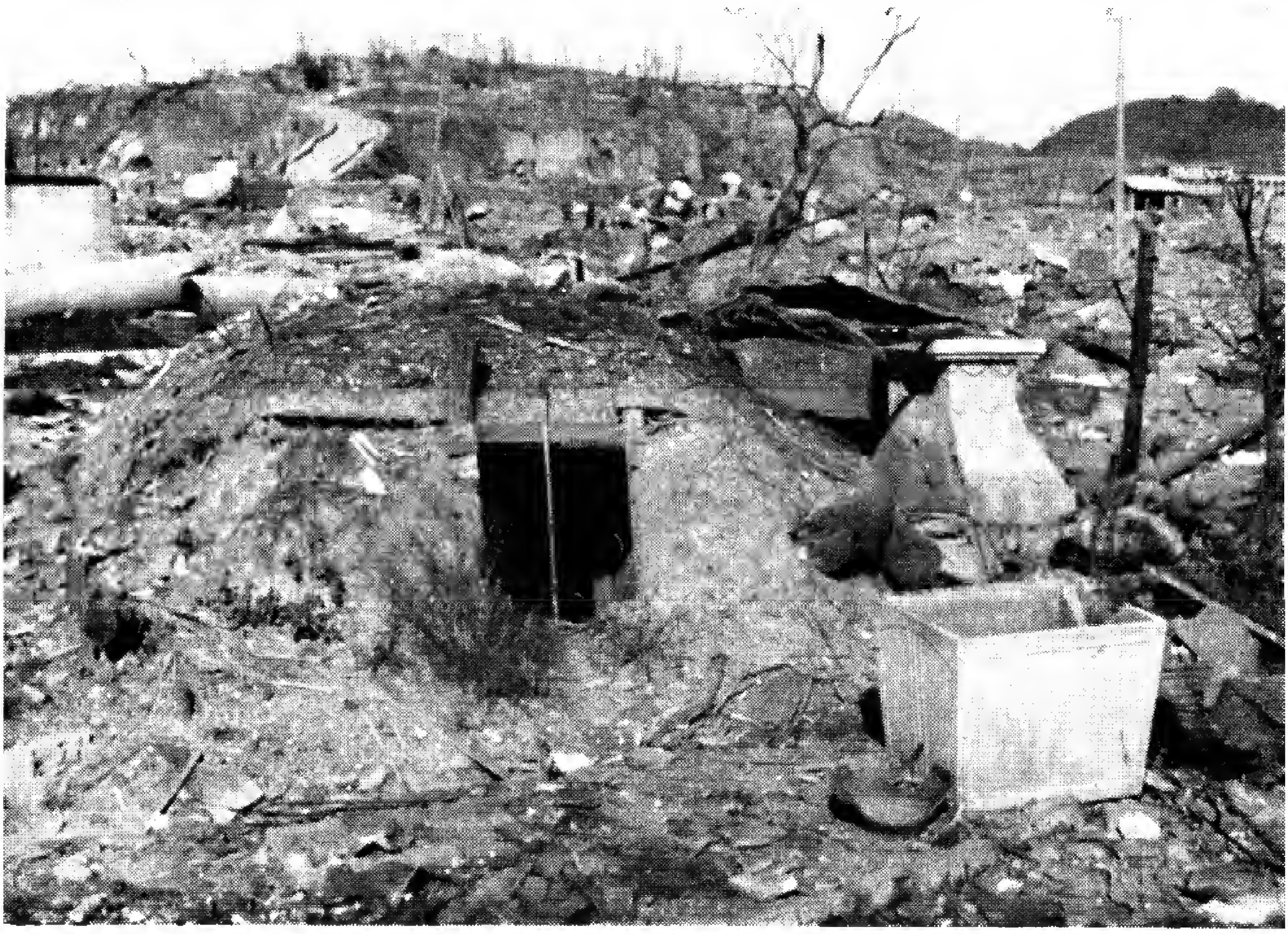
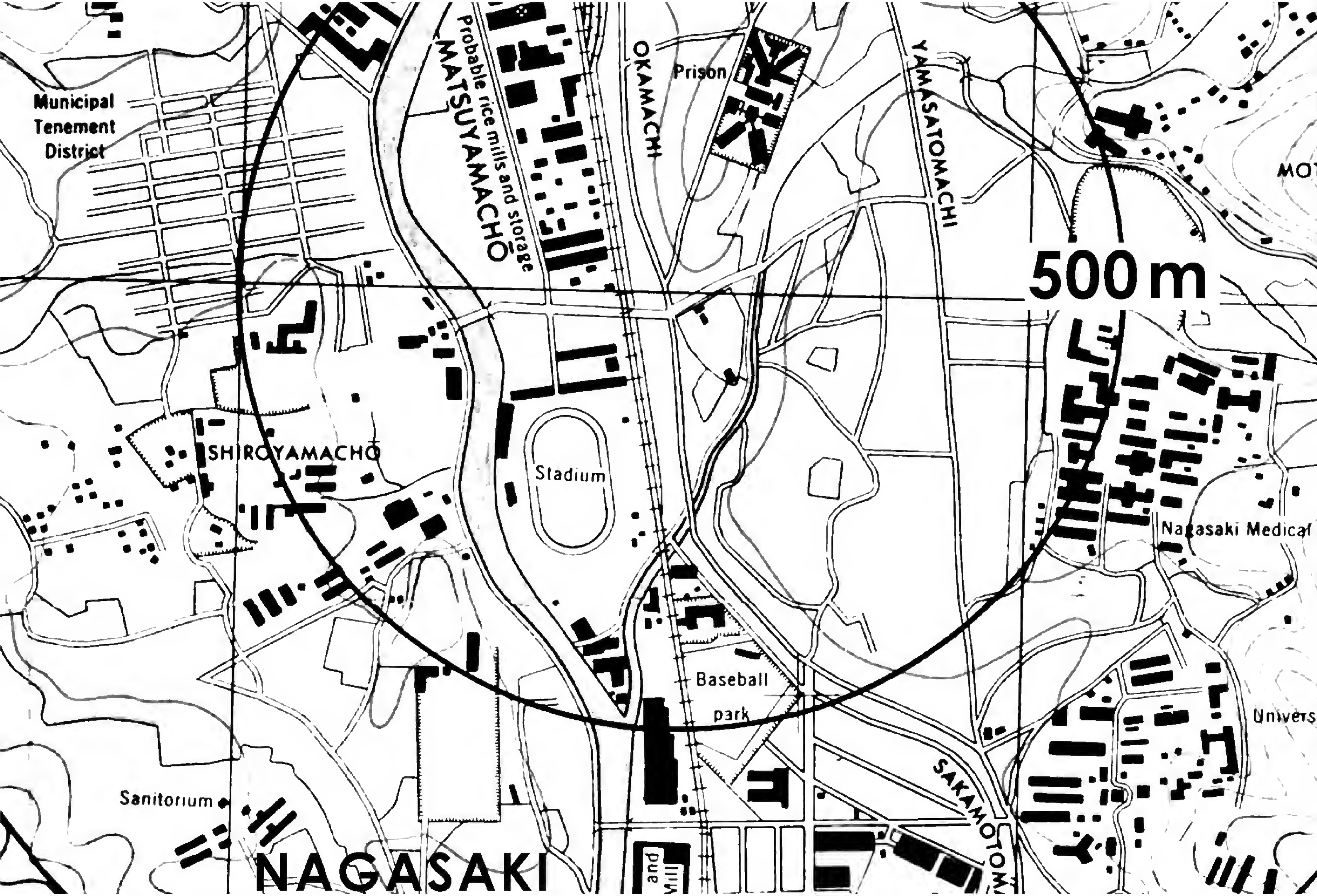


Photo No. 18. NAGASAKI. Typical small earth-covered back yard shelter with crude wooden frame, less than 100 yds. from the centre of damage, which is to the right. There was a large number of such shelters, but whereas nearly all those as close as this one had their roofs forced in, only half were damaged at 300 yds., and practically none at half a mile from the centre of damage.


500 m
Municipal
Tenement
District
Probable rice mills and storage
MATSUYAMACHŌ
OKAMACHI
Prison
YAMASATOMACHI
SHIROYAMACHO
Stadium
Baseball
park
Nagasaki Medical
Univers
SAKAMOTOMA
Sanitorium
NAGASAKI


15
2000
12
1000
GROUND ZERO
17
16
20
18
22

Tunnel shelters in hillside, very close to ground zero in Nagasaki, protected the occupants from blast, thermal radiation, and immediate nuclear radiation.

3rd October, 1963. ~~RESTRICTED~~ For Pr

HOME OFFICE

SCIENTIFIC ADVISER'S BRANCH

CD/SA 116

RESEARCH ON BLAST EFFECTS IN TUNNELS

With Special Reference to the Use of London Tubes as Shelter

by F. H. Pavry

Summary and Conclusions

The use of the London tube railways as shelter from nuclear weapons raises many problems, and considerable discussion of some aspects has taken place from time to time. But - until the results of the research here described were available - no one was able to say with any certainty whether the tubes would provide relatively safe shelter or not.

The more recent research here described showed for the first time that a person sheltering in a tube would be exposed to a blast pressure only about ⅓ as great as he would be exposed to if he was above ground. (In addition, of course, he would be fully protected from fallout in the tube.)

Large-Scale Field Test (1/40) at Suffield, Alberta

The test is fully described in an A.W.R.E. report[6]. The decision of the Canadian Defence Research Board to explode very large amounts of high explosive provided a medium for a variety of target-response trials that was welcome at a time when nuclear tests in Australia were suspended. A.W.R.E. used the 100-ton explosion in 1961 to test, among other items, the model length of the London tube, at 1/40th scale, that had already been tested at 1/117 scale.

Blast Entry from Stations

There was remarkable agreement with the 1/117th scale trials: "maximum overpressure in the train tunnels was of the order of ⅓rd the corresponding peak shock overpressure in the incident blast. The pressures in the stations were about 1/6th those in the corresponding incident blast .... ".

(6) 1/40th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System. A.W.R.E. Report E2/62. (Official Use Only.)

100 ton TNT test on 1000 ft section of London Underground tube at Suffield, Alberta, 3 Aug 1961

Atomic Weapons Research Establishment, "1/40th Scale Experiment to Assess the Effect of Nuclear Blast on the London Underground System", Report AWRE-E2/62, 1962, Figure 30. (National Archives ES 3/57.)

200 FT FROM GROUND ZERO	400 FT FROM GROUND ZERO
100 PSI OUTSIDE	20 PSI OUTSIDE
30 PSI IN TUBES	7.2 PSI IN TUBES
15 PSI IN TUBE STATIONS	4.3 PSI IN TUBE STATIONS

Aldwych Underground tube station as Blitz shelter, 8 October 1940

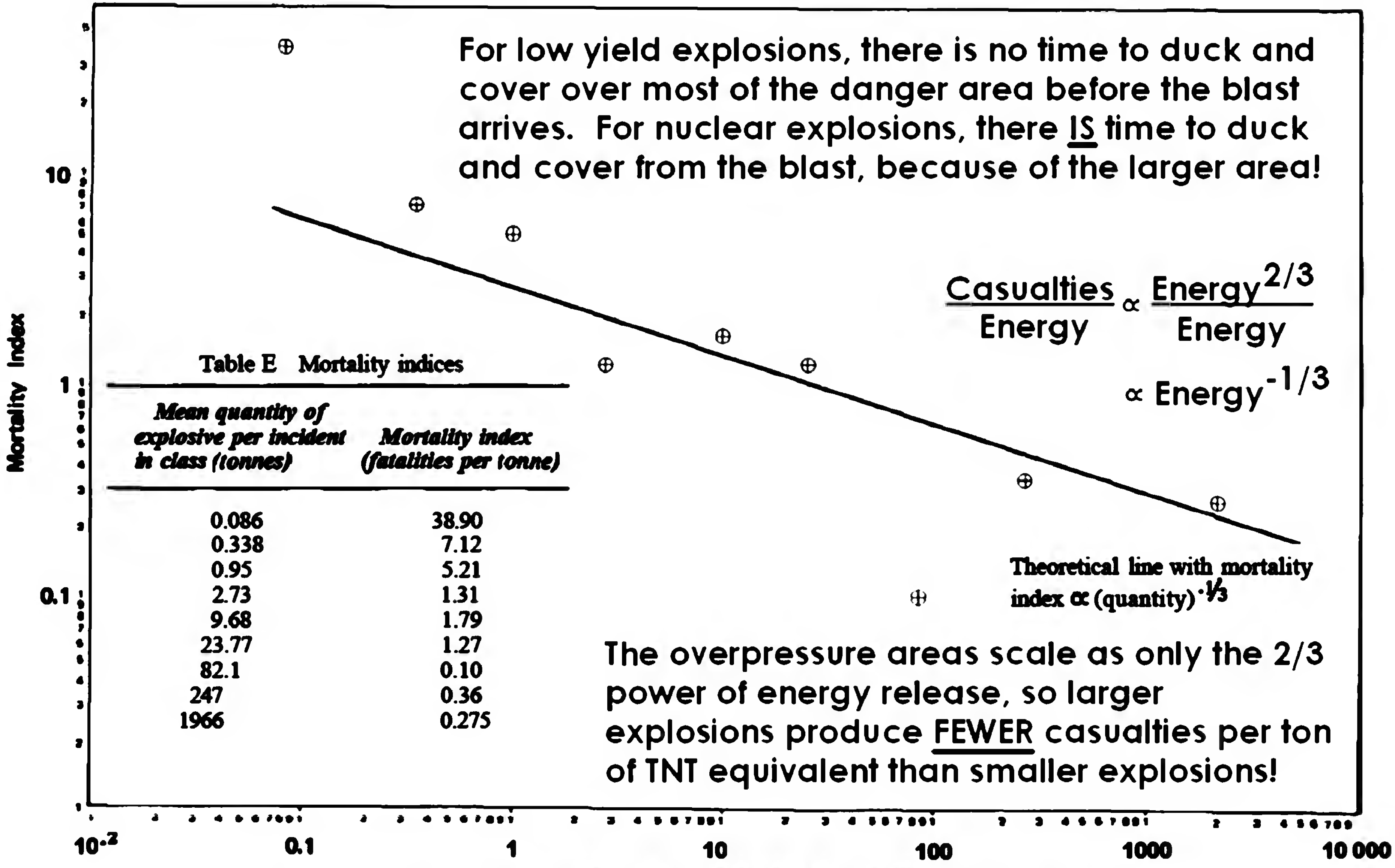


Table E Mortality indices

Mean quantity of explosive per incident in class (tonnes)	*Mortality index (fatalities per tonne)*
0.086	38.90
0.338	7.12
0.95	5.21
2.73	1.31
9.68	1.79
23.77	1.27
82.1	0.10
247	0.36
1966	0.275

Fig 3 Variation of mortality index with size of incident for explosives (from table E)

Health & Safety Commission

Advisory Committee on Major Hazards

SECOND REPORT

HER MAJESTY'S STATIONERY OFFICE *1979*

UK NATIONAL ARCHIVES: HO225/16 (1950)

THE NUMBER OF ATOMIC BOMBS EQUIVALENT TO THE LAST WAR AIR ATTACKS ON GREAT BRITAIN AND GERMANY

Summary

During the last war, a total of 1,300,000 tons* of bombs were dropped on Germany by the Strategic Air Forces. If there were no increase in aimi accuracy, then to achieve the same total amount of material damage (to houses, industrial and transportation targets, etc.) would have required the use of over 300 atomic bombs together with some 500,000 tons of high explosive and incendiary bombs for targets too small to warrant the use of an atomic bomb. Increases in accuracy could cause a substantial reduction in this figure of 300 atomic bombs, to as few as 100-150 bombs for very accurate attacks.

AIR MINISTRY
AP 3349

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WO
CODE No.
9466

26/GS Trg Publications/2329

PRECAUTIONS AGAINST NUCLEAR ATTACK

1957

(Superseding Precautions Against Atomic Attack, 1952 (WO Code No. 8769))

Promulgated by Command of the Army Council,

E. W. Playfair

Promulgated by Command of the Air Council,

J. H. Barnes

Telegraph pole burnt on the side facing the flash. Note where foliage has acted as a shield

Shelter 100 yards from the centre of damage—Nagasaki

Protection against fall-out

101. Except in the immediate vicinity of a nuclear explosion a reasonably accurate prediction of the area of fall-out can be made in time for a warning to be issued to units in the areas in which it is likely to fall. Given a reasonable warning it may be possible to evacuate the area before the fall-out arrives. In any case simple precautionary measures can greatly reduce the hazard to life.

102. Exposure to the radio-active radiations from fall-out can be reduced by taking shelter and by using simple decontamination procedures until such time as persons can leave the area. In areas where radio-active contamination is heavy it may be necessary to remain under cover for as long as 48 hours before the radiations will have fallen, by natural decay, to levels at which it will be safe for persons to move about, either to leave the area, or, in the case of rescue teams from other areas, to enter it.

103. The estimated degree of protection against the residual radiation to be obtained from buildings, trenches, etc, in a fall-out area is shown at Table 7:—

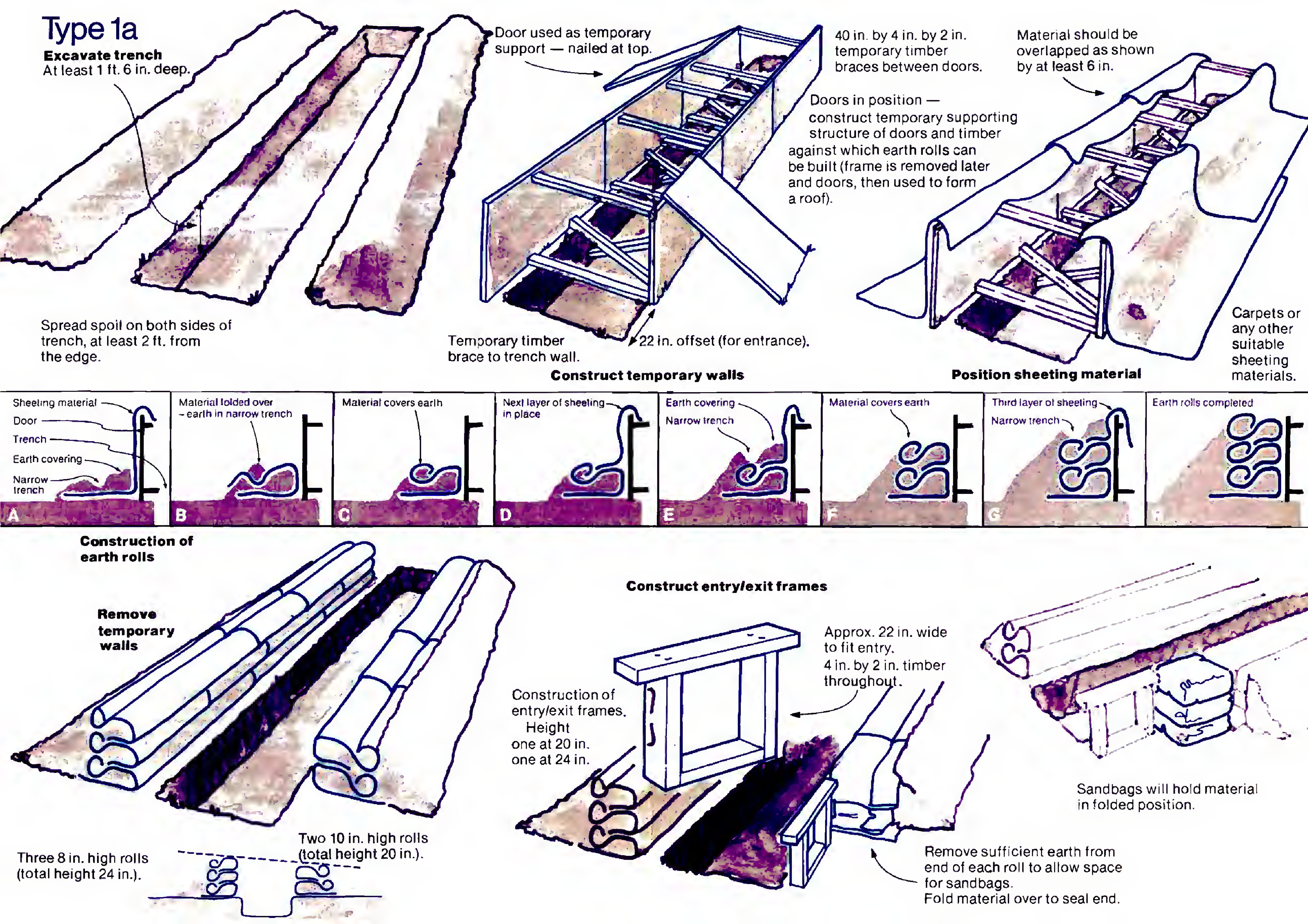
TABLE 7. **Estimated degree of protection against the residual radiation to be obtained from various buildings, trenches, etc, in a fall-out area**

Type of building or shelter	INSIDE dose expressed as a fraction of the OUTSIDE dose	
Slit trench with light board or corrugated iron overhead	$\frac{1}{2}$	
Slit trench with 1 ft of earth overhead	$\frac{1}{100}$	
Slit trench with 2 ft to 3 ft of earth overhead	$\frac{1}{200}$ to $\frac{1}{300}$	
Nissen hut	$\frac{1}{2}$	
One storey brick house	$\frac{1}{10}$ to $\frac{1}{20}$	dependent upon wall thickness and shielding afforded by neighbouring houses
Two storey brick house	$\frac{1}{10}$ to $\frac{1}{50}$	
Three storey brick house	$\frac{1}{15}$ to $\frac{1}{100}$	
Average two storey house in a built up area	$\frac{1}{40}$	
Basements	$\frac{1}{200}$ to $\frac{1}{300}$	dependent upon shielding afforded by neighbouring houses

DOMESTIC NUCLEAR SHELTERS

Advice on
domestic shelters
providing protection
against
nuclear explosions

A Home Office guide



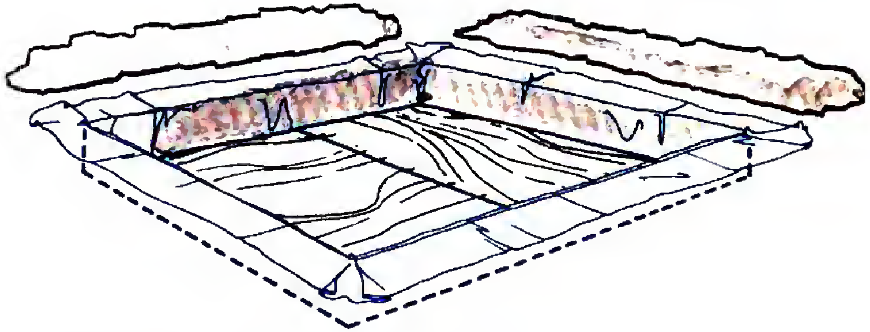
Type 1a
Excavate trench
At least 1 ft. 6 in. deep.
Spread spoil on both sides of trench, at least 2 ft. from the edge.
Door used as temporary support — nailed at top.
40 in. by 4 in. by 2 in. temporary timber braces between doors.
Doors in position — construct temporary supporting structure of doors and timber against which earth rolls can be built (frame is removed later and doors, then used to form a roof).
Temporary timber brace to trench wall.
22 in. offset (for entrance).
Construct temporary walls
Material should be overlapped as shown by at least 6 in.
Carpets or any other suitable sheeting materials.
Position sheeting material
Sheeting material
Door
Trench
Earth covering
Narrow trench
A
Material folded over – earth in narrow trench
B
Material covers earth
C
Next layer of sheeting in place
D
Earth covering
Narrow trench
E
Material covers earth
F
Third layer of sheeting
Narrow trench
G
Earth rolls completed
Construction of earth rolls
Remove temporary walls
Three 8 in. high rolls (total height 24 in.).
Two 10 in. high rolls (total height 20 in.).
Construct entry/exit frames
Construction of entry/exit frames. Height one at 20 in. one at 24 in.
Approx. 22 in. wide to fit entry.
4 in. by 2 in. timber throughout.
Sandbags will hold material in folded position.
Remove sufficient earth from end of each roll to allow space for sandbags.
Fold material over to seal end.

Type 1a earth-covered doors-over trench shelter
Home Office Scientific Advisory Branch (Home
Defence College, Easingwold, York, 1980)

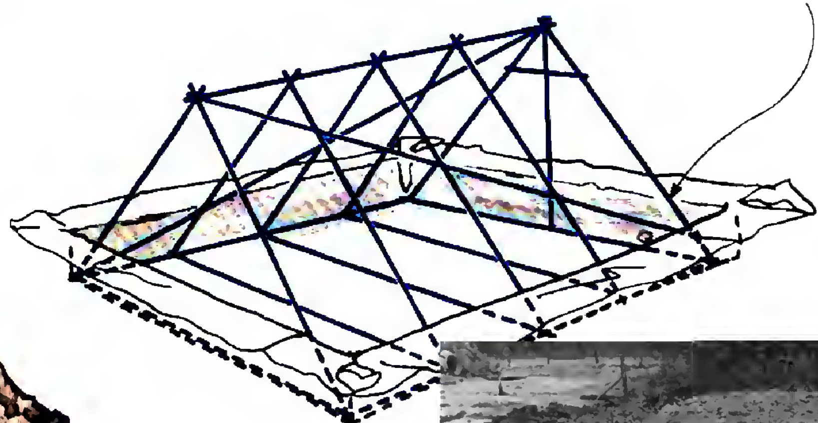
Type 1b

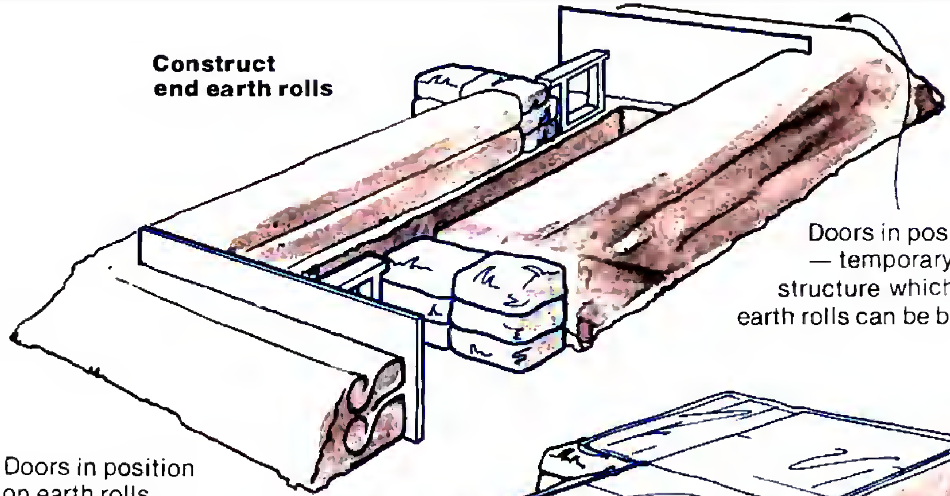
Improvised outdoor shelter

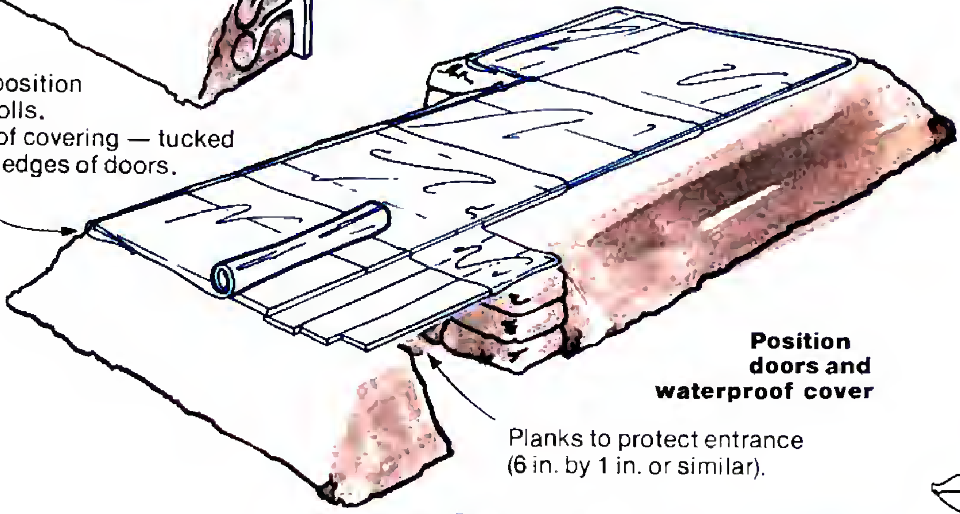
Prepare a trench 8 ft. x 8 ft. and at least 1 ft. 6 in. deep. Line it with heavy duty polythene sheeting. Lay a floor of two sheets of plywood, ¾ in. thick and 4 ft. x 8 ft.

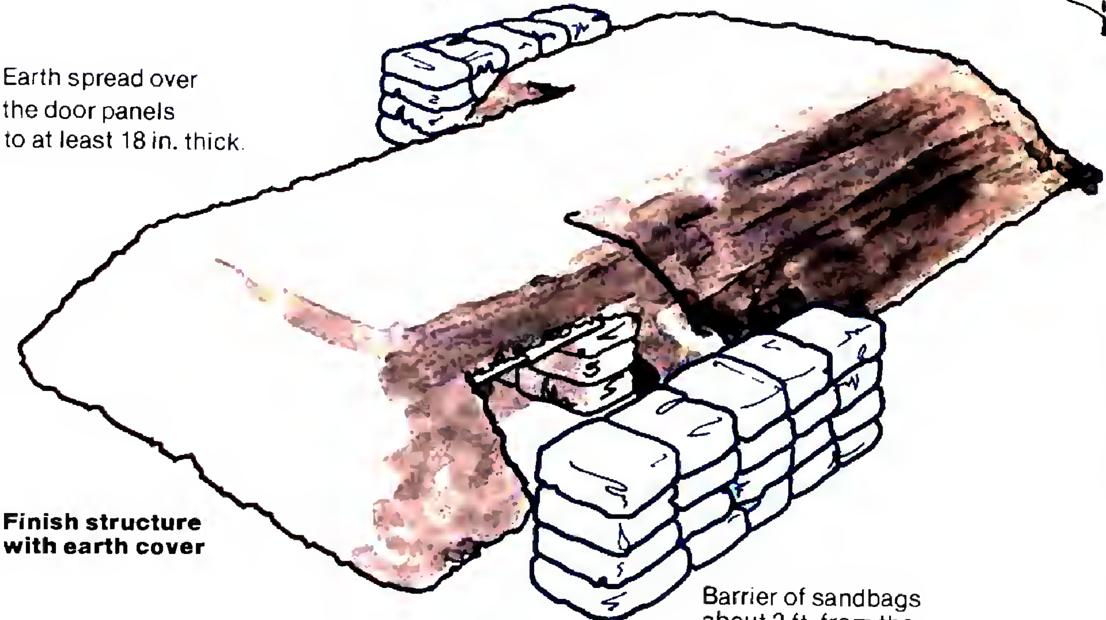


Construct the frame of scaffold poles (or you could use wood). This should be as strong as you can make it. You can increase the strength with vertical and diagonal bracing, or crossbars.





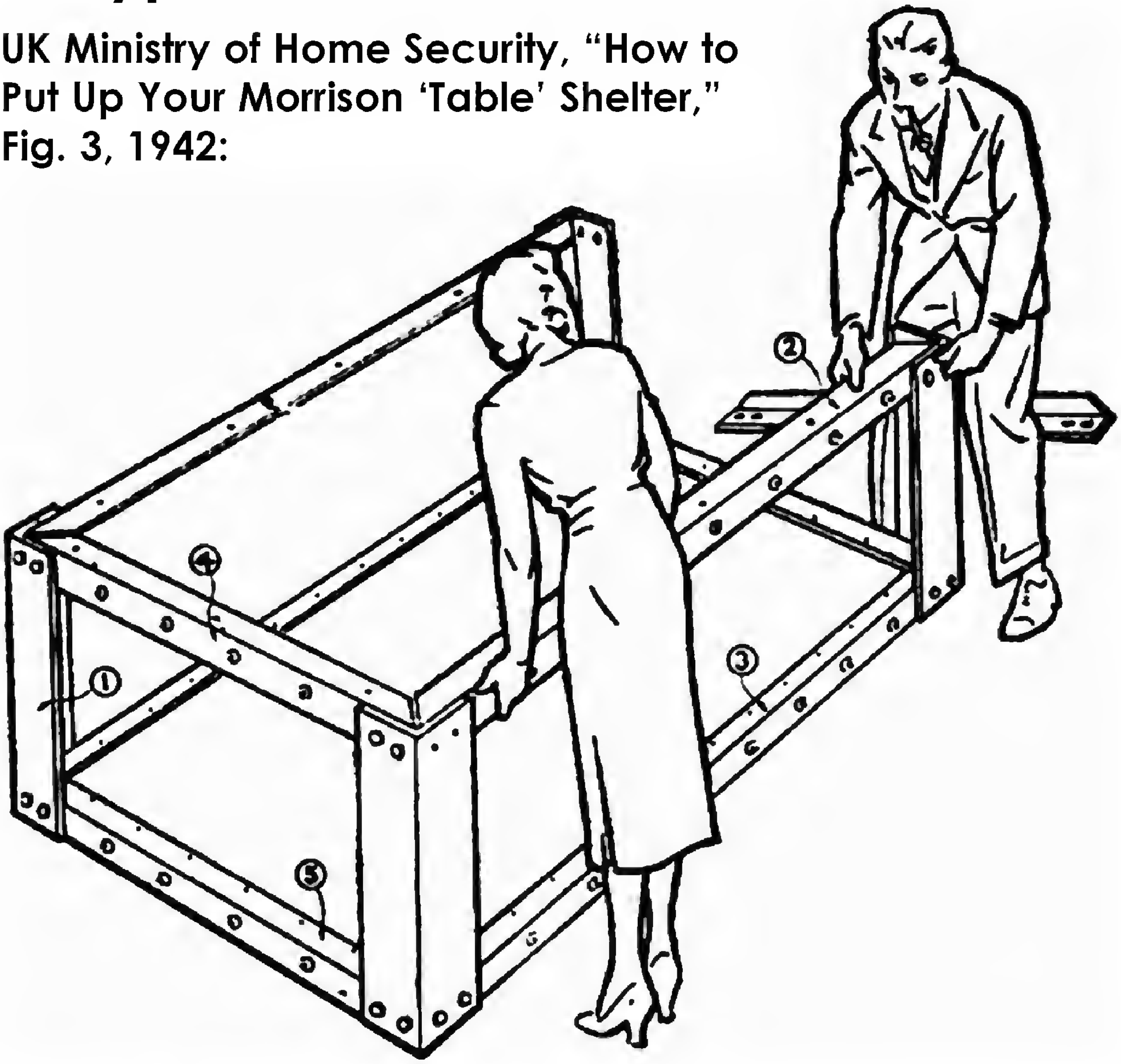




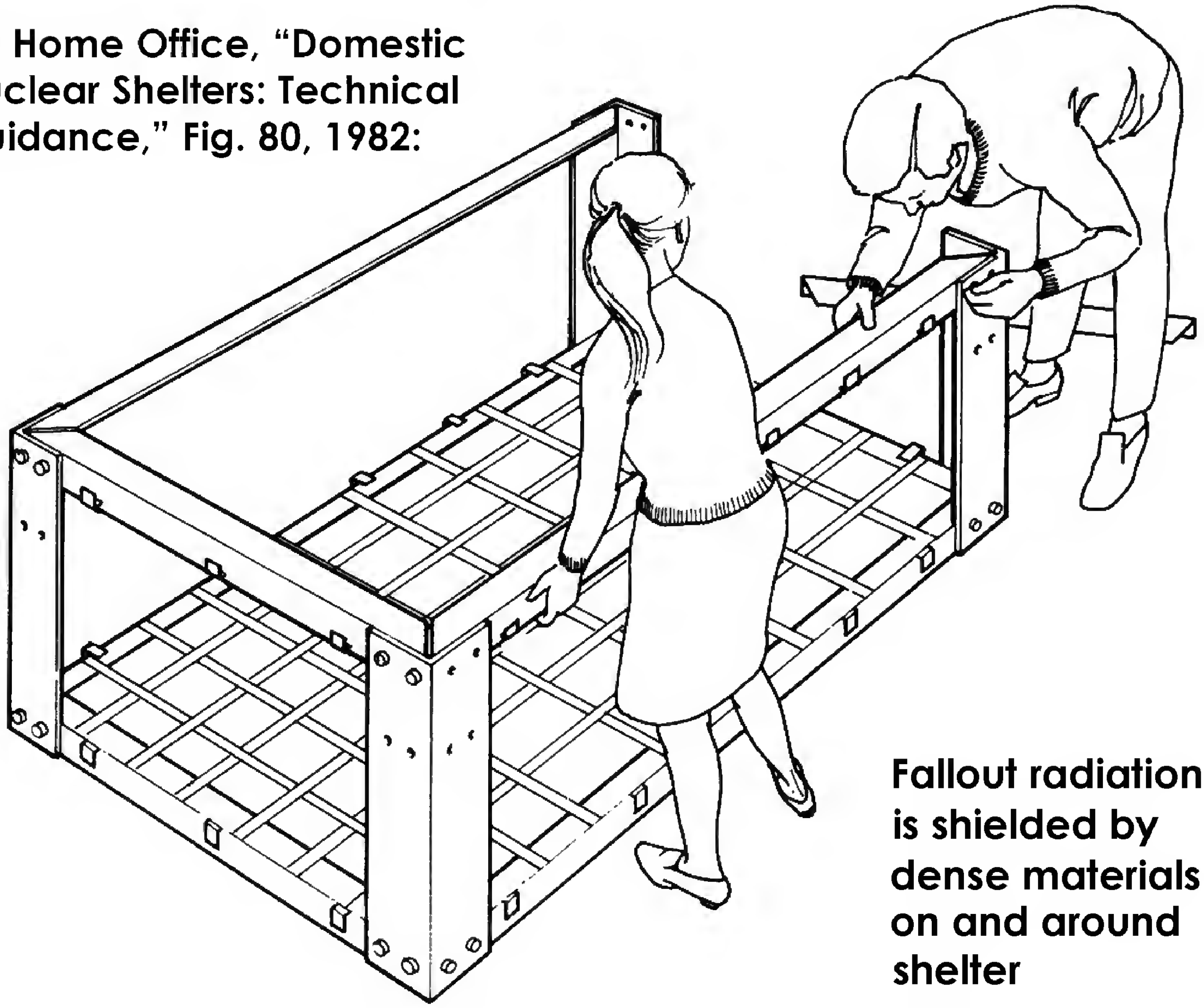
Type 1b earth-covered scaffold/wood pole A-frame shelter, in 1980 at Home Defence College, Easingwold, York

Type 2 indoor Morrison shelter

UK Ministry of Home Security, "How to Put Up Your Morrison 'Table' Shelter," Fig. 3, 1942:



UK Home Office, "Domestic Nuclear Shelters: Technical Guidance," Fig. 80, 1982:



Fallout radiation is shielded by dense materials on and around shelter

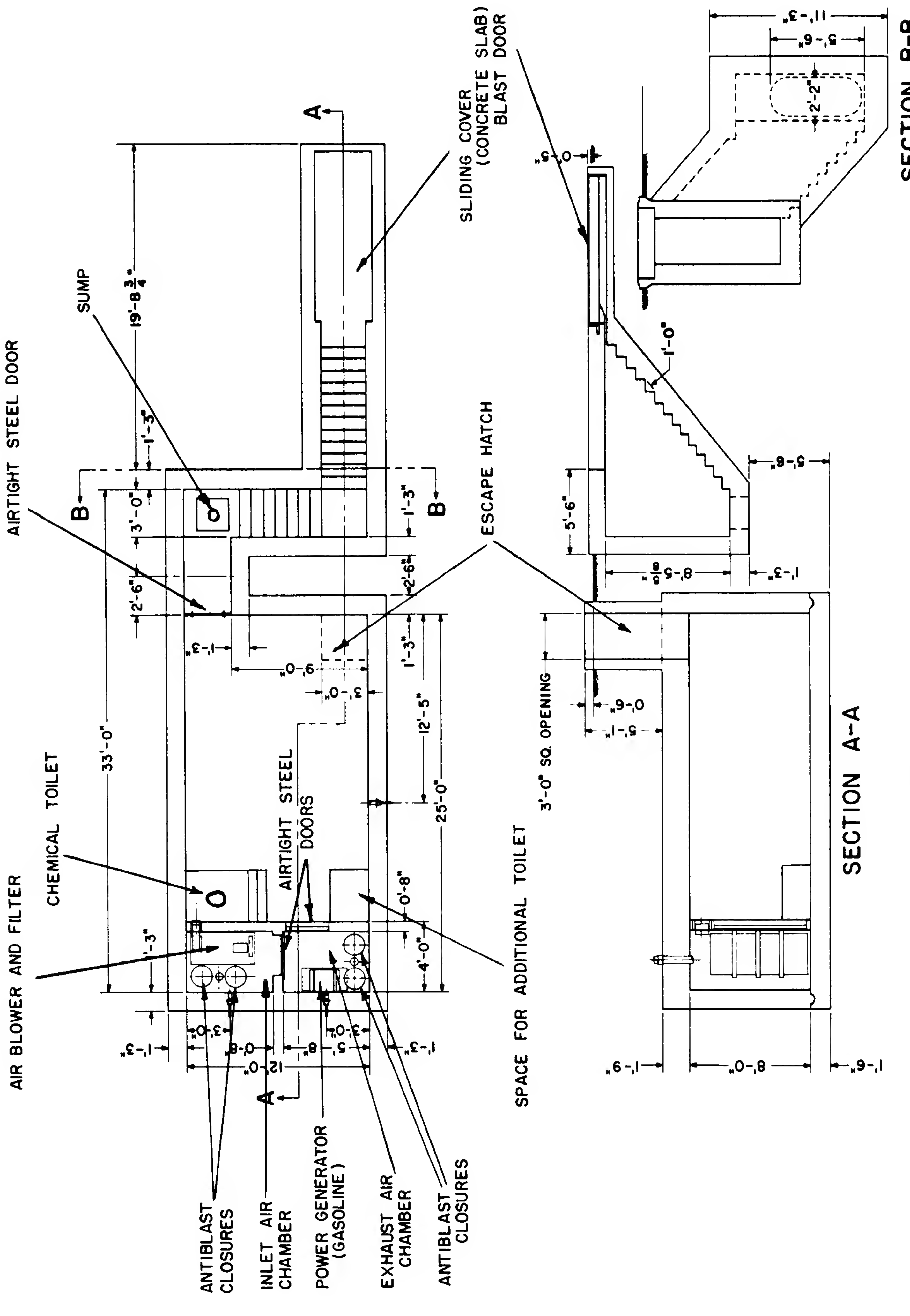
Type 3 outdoor Anderson shelter

Anderson shelters exposed to Operation Hurricane nuclear test

Anderson shelter with earth cover (not sandbags) and radiation-shielded entrance at Home Defence College, Easingwold, York, 1980.

Earth covered shelter, Hiroshima (U.S. Strategic Bombing Survey)

Type 4 reinforced concrete shelter (Nevada bomb test)
Fig. 12.54 in Glasstone Effects of Nuclear Weapons, 1957



Sectional plan and section of underground personnel shelter

COPY No. 15
14 PAGES

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AWRE – T1/53

Wd 22/10/84 . SCO 468 refers

NATIONAL ARCHIVES
ES5/1

MINISTRY OF SUPPLY

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

REPORT No. T 1/53
(HURRICANE)

B. 0134

DECLASSIFIED FOR PR
BY AWE ALDERMASTON

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A.W.R.E.
Aldermaston Berks.

[redacted]

May, 1953

3.2 Blast Damage

Outdoor peak overpressure was 51 psi at 500 yds, 25 psi at 665 yds and 10 psi at 1,000 yds 3 psi extended to 2,000 yds

3.2.1 Anderson Shelters

Standard Anderson Shelters, with sandbag covering and blast wall construction were locat.;d at 460, 510, 600, 920 and 1,130 yards from ground zero. Mean blast pressures, in pounds/sq. inch, recorded inside the shelters are shown in the following table.

Distance (yds.)	Presentation		
	Front	Side	Rear
460	NR	NR	NR
510	38	27	40
600	28	21	28
920	16	7	14
1130	8.5	4	5.5

Front presentation implies blast wall facing towards event.
Rear " " " " " away from event.
Side " " shelter side on to event.

Shelters at 460, 510 and 600 yards suffered damage including demolition of blast walls, removal of sandbag covering and some displacement of the corrugated iron.

At 920 and 1,130 yards the shelters suffered relatively little damage.

Civil defence authorities consider that there might have been some 50% survival from blast damage of personnel in shelters at 460 yards and some 90 per cent at 600 yards, fatal casualties being mainly due to secondary blast effects (e.g. debris) and not to direct effects on the person of the blast pressure itself. The front presentation appears the most hazardous, due to the collapse of the blast wall into the shelter. At such distances, however, the survival from the effects of gamma flash would have been virtually nil. (MORE EARTH COVER IS NEEDED FOR RADIATION.)

At 920 and 1,130 yards there would have been no casualties from blast, and incidentally, little risk from the effect of gamma flash.

UK NATIONAL ARCHIVES: ES 5/2

ANDERSON SHELTER TESTS AGAINST 25 KT NUCLEAR NEAR SURFACE BURST (2.7 METRES DEPTH IN SHIP)

AWRE-T1/54, 27 Aug. 1954

SECRET—GUARD

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

(formerly of Ministry of Supply)

SCIENTIFIC DATA OBTAINED AT OPERATION HURRICANE

(Monte Bello Islands, Australia—October, 1952)

$$p = \frac{130 \times 10^9}{R^3} + \frac{7 \cdot 7 \times 10^6}{R^2} + \frac{13 \cdot 5 \times 10^3}{R}$$

p is the maximum excess pressure in p.s.i. and R is the distance in feet

Fig. 12.1, Andersons at 1380 ft range from bomb ship shown in the photo, moored 400 yards off shore.

Left: Fig. 12.3, Andersons at 1800 ft after burst. Right: Fig. 12.4, Andersons protected by blast walls at 2760 ft.

12.1. *Blast Damage to Anderson Shelters*

Sandbags failed to provide any earth-arching protection

At 1,380 feet, Fig. 12.1, parts of the main structure of the shelters facing towards and sideways to the explosion were blown in but the main structure of the one facing away from the explosion was intact, and would have given full protection. At 1,530 feet, Fig. 12.2, the front sheets of the shelter facing the explosion were blown into the shelter but otherwise the main structures were more or less undamaged, as were those at 1,800 feet, Fig. 12.3.

At 2,760 feet, Fig. 12.4, some of the sandbags covering the shelters were displaced and the blast walls were distorted whilst at 3,390 feet, Fig. 12.5, the effect was quite small. At these distances, the shelters were not in direct view of the explosion owing to intervening sandhills.

13. The Penetration of the Gamma Flash

13.1. *Experiments on the Protection from the Gamma Flash afforded by Slit Trenches*

13.1.1. The experiments described in this section show that slit trenches provide a considerable measure of protection from the gamma flash. From the point of view of Service and Civil Defence authorities this is one of the most important results of the trial.

13.1.2. Rectangular slit trenches 6 ft. by 2 ft. in plan and 6 ft. deep were placed at 733, 943 and 1,300 yards from the bomb and circular fox holes 2 ft. in radius and 6 ft. deep were placed at 943 and 1,300 yards.

The doses received from the flash were measured with film badges and quartz-fibre dosimeters in order to determine the variation of protection with distance, with depth and with orientation of the trench and the relative protection afforded by open and covered trenches.

In general, the slit trenches were placed broadside-on to the target vessel but at 1,300 yards one trench was placed end-on. Two trenches, one at 733 and one at 943 yards were covered with the equivalent of 11 inches of sand.

Table 13.1

Variation of Gamma Flash Dose on Vertical Axis of Trench

Type of trench	Rectangular broadside-on open			Rectan-gular end-on open	Circular open		Rectangular broadside-on covered	
Distance (yards) ...	1,300	943	733	1,300	1,300	943	943	733
Surface dose (Roentgens)	300	3,000	14,000	300	300	3,000	3,000	14,000
Depth below ground level (inches)								
6 ...	150	1,000	—	230	214	1,200	(75)	—
12 ...	75	430	—	150	120	545	47·6	—
24 ...	33·3	150	584	60	54·5	188	25	(140)
36 ...	23	70	216	31·6	30	86	13	(56)
48 ...	(20)	43	100	20	17·7	48·5	7·7	(31)
60 ...	—	(37·5)	61	13·6	10·7	(33·3)	5	(23)
72 ...	—	—	(46·7)	(8·6)	7	—	(3·5)	—

Entries in brackets are extrapolations or estimates.

Trench air raid shelter in Kent hop field 15 Aug 1940

Exercise Desert Rock VI (Nevada, 1955), 6 ft trench at 4,000 yds from GZ

Nevada test site, 8 May 1953: 27 kiloton ENCORE nuclear weapon test

1 HB–8
The house at Main and Elm Streets. Two typical colonial two-story center hall frame dwellings were placed at 3,500 and 7,500 feet from the bomb tower. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

X–19
This mannequin can only stay in the position in which he was placed, staring through the window at coming disaster. A real occupant of this house could prepare—and survive. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

1 HA–11
House No. 1, from the camera tower from which the dramatic collapse pictures were taken. The Post Office truck to the left, although it lost all windows and suffered body damage, was driven away later, as was the car in the rear of the house. Entry to the basement was made through the corner at lower center. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

LSA–2
3,500 feet from ground zero. The house overhead is totally destroyed, some of it has fallen into the basement, but the mannequin in the lean-to shelter is undisturbed. The photo was taken from ground level, looking into the basement through the gap between the basement wall and the broken floor timbers. (FCDA—Operation Doorstep—Yucca Flat, Nev., Mar. 17, 1953.)

HOME OFFICE

CD/SA 121

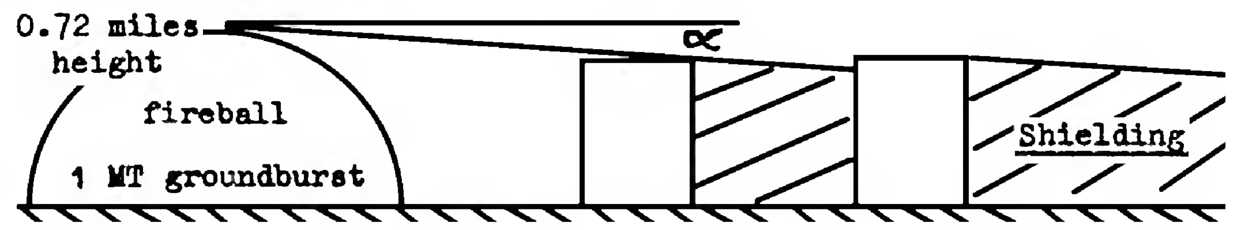
SCIENTIFIC ADVISER'S BRANCH

(Paper at Tripartite Thermal Effects Symposium, Dorking, October 1964)

IGNITION AND FIRE SPREAD IN URBAN AREAS FOLLOWING A NUCLEAR ATTACK

G. R. Stanbury

INITIAL FIRE INCIDENCE



Thermal pulse precedes the blast wave

Assuming that buildings on opposite sides of a street which is receiving heat radiation from a direction perpendicular to its length are of the same height we take the average depth of a floor to be 10 ft.

Effect of Shielding: Estimation of the number of exposed floors

Distance from explosion miles	Angle of arrival α^{o}	Width of street (units of 10 ft.) 2	3	4	5	6	7	8
3	$13\frac{1}{2}$	.5	.5	1	1	1.5	1.5	2
4	10	.5	.5	.5	1	1	1.5	1.5
5	8	.5	.5	.5	.5	1	1	1

SPREAD OF FIRE

From last war experience of mass fire raids in Germany it was concluded that the overall spread factor was about 2; i.e. about twice as many buildings were destroyed by fire as were actually set alight by incendiary bombs

Number of fires started per square mile in the fire-storm raid on Hamburg, 27th/28th July, 1943

102 tons H.E.	48 tons, 4 lb. magnesium	40 tons, 30 lb. gel.
100 fires	27,000 bombs	3,000 bombs
	8,000 on buildings	900 on buildings
	1,600 fires	800 fires

2,500 fires in 6,000 buildings

However, the important thing to note is that the total number of fires started in each square mile (2,500) was nearly half that of the total number of buildings; in other words, almost every other building was set on fire

When the figure of 1 in 2 for the German fire storms is compared with the figures for initial fire incidence of ~ 1 in 15 to 30 obtained in the Birmingham and Liverpool studies it can only be concluded that a nuclear explosion could not possibly produce a fire storm.

SECONDARY FIRES FROM BLAST DAMAGE IN LONDON

Fire situation from 1,499 fly bombs in the built-up part of the London Region

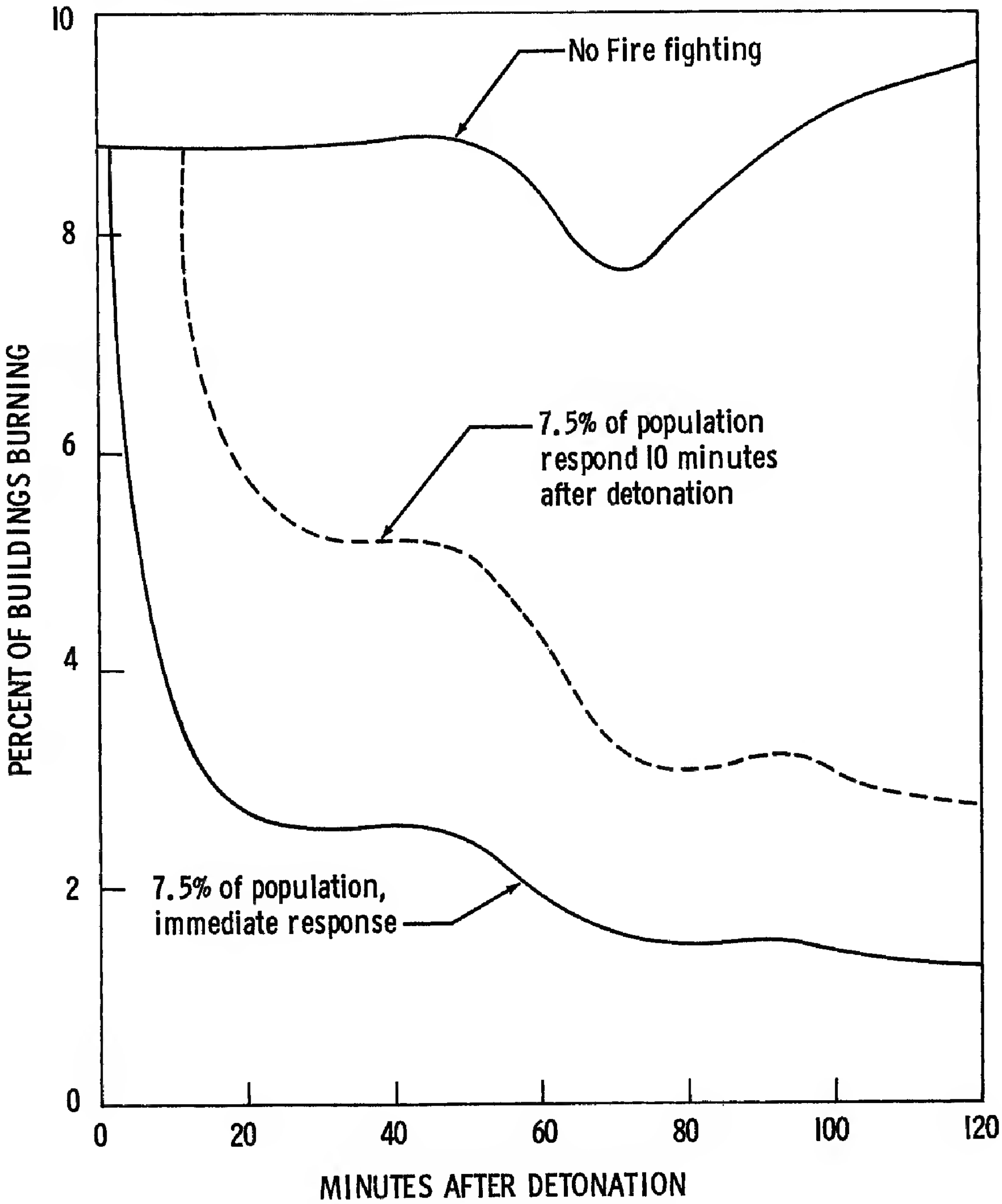
(Fires from 1 ton TNT V1 cruise missiles, 1944)

	Number of fly bombs	Fly Bombs Caused				
		No fire	Small fire	Medium fire	Serious fire	Major fire
Grand Totals	1,499	804	609	75	7	4

The large proportion started no fires at all even in the most heavily built-up areas.

All these fly bombs fell in the summer months of 1944 which were unusually dry. In winter in this country in residential areas there are many open fires which may provide extra sources of ignition. The domestic occupancy is a low fire risk however, and as the proportion of such property in the important City and West End areas is small this should not introduce any serious error. Moreover, in winter, the high atmospheric humidity and the correspondingly high moisture content of timber would tend to retard or even prevent the growth of fire.

Takata, A.N., Mathematical Modeling of Fire Defenses, IITRI, March 1970, AD 705 388.



ADA038738

Secondary Fires

Secondary fires are those that result from airblast damage. Their causes include overturned gas appliances, broken gas lines, and electrical short-circuits. McAuliffe and Moll (Reference 1) studied secondary fires resulting from the atomic attacks on Hiroshima and Nagasaki and compared their results with data from conventional bombings, explosive disasters, earthquakes, and tornadoes. Their major conclusion was that secondary ignitions occur with an overall average frequency of 0.006 for each 1000 square feet of floor space, provided airblast peak overpressure is at least 2 psi. The frequency of secondary ignitions appears to be relatively insensitive to higher overpressures.

Based on surveys of Hiroshima and Nagasaki buildings.

FREQUENCY OF SECONDARY IGNITIONS AS A FUNCTION OF BUILDING TYPE

Type of Structure	Frequency of Secondary Ignitions (for each 1,000 square feet of floor area)
Wood	0.019
Brick	0.017
Steel	0.004
Concrete	0.002

MULTIPLYING FACTOR FOR TYPES OF BUILDING OCCUPANCIES

Type of Occupancy	Multiplying Factor
Public	0.4
Mercantile	0.5
Residential	0.5
Manufacturing	1.0
Miscellaneous	10.0

MULTIPLYING FACTOR FOR TIME OF DAY

Time of Day	Multiplying Factor
Night	0.5
Day (other than mealtimes)	1.0
Mealtimes	2.0

1 . Secondary Ignitions in Nuclear Attack, J. McAuliffe and K. Moll, Stanford Research Institute, Menlo Park, California 94025, SRI Project 5106 (AD 625173), July 1965.

OFFICE OF THE AIR SURGEON

NP-3041

MEDICAL EFFECTS OF ATOMIC BOMBS

The Report of the Joint Commission for the Investigation of the Effects of the Atomic Bomb in Japan; Volume VI

By
Ashley W. Oughterson
George V. LeRoy
Averill A. Liebow
E. Cuyler Hammond
Henry L. Barnett
Jack D. Rosenbaum
B. Aubrey Schneider

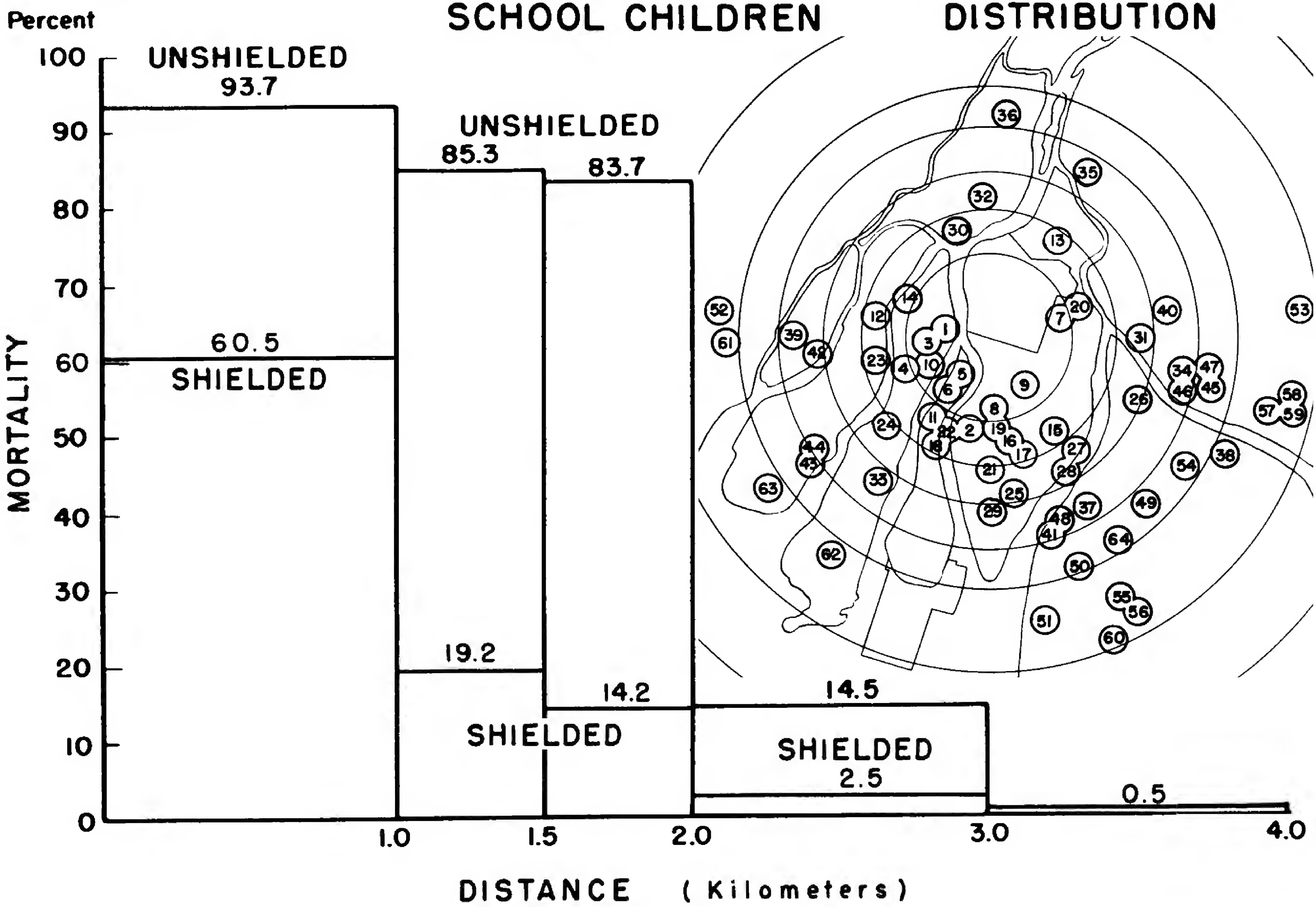
July 6, 1951
[TIS Issuance Date]

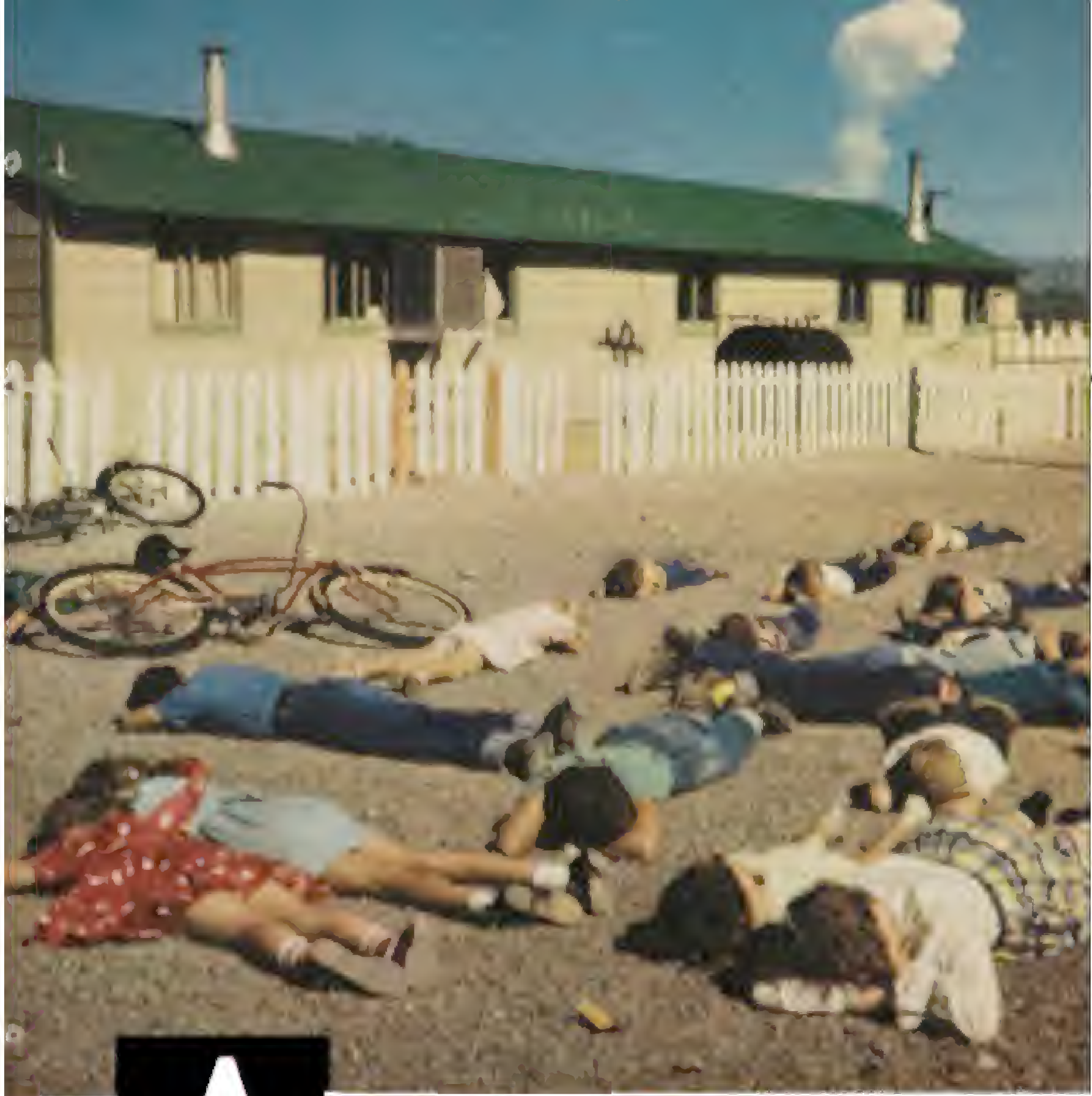
Army Institute of Pathology

UNITED STATES ATOMIC ENERGY COMMISSION
Technical Information Service, Oak Ridge, Tennessee

HIROSHIMA SCHOOL CHILDREN

WORK PARTIES DISTRIBUTION





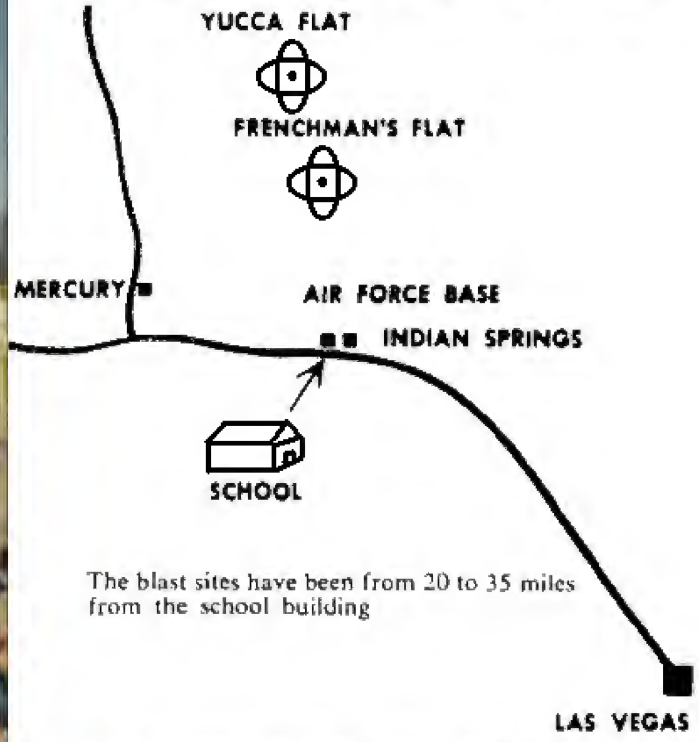
A IS FOR ATOM

By ROBERT CAHN

A dozen times, the awesome mushroom has risen in view of these youngsters, 25 miles from the Nevada test sites. Here's the story of our most atom-wise kids

Collier's Weekly, June 21, 1952, pp. 15-17

Indian Springs (whose permanent population is 17) and adjacent air base are 42 miles from Las Vegas



The blast sites have been from 20 to 35 miles from the school building

SEVERAL months ago, the people of the nation learned with some interest that for the first time combat troops were to witness an atomic bomb test from close up. But to the youngsters at Indian Springs Public School, near Las Vegas, Nevada, such an experiment was old-hat. They already had seen, from less than 25 miles away, more atomic bomb blasts than anyone in the world except for the handful of nuclear scientists and technicians who set them off.

Starting last October, when the influx of atomic, military and construction personnel brought more than 200 families into the area, the Indian Springs school had become an unplanned experiment in the indoctrination of young children to atomic bombs.

"The children at this school, by their sheer proximity to the tests, are getting the same type of psychological indoctrination we are giving some of our combat troops," an Atomic Energy Commission spokesman commented recently. "If all the school children in the nation could witness an A-bomb blast, it would do much to destroy the fear and uncertainty which now exist."

Eighth-grader Dick Bower, thirteen, says he was once told at an atomic bomb drill in a southern California school that there was a possibility the whole earth could be blown up if enough such bombs were exploded. "I was really scared when we moved up here," Dick says, "but I have seen a couple of bombs go off now and it's just ordinary."

(US Strategic Bombing Survey, 1946 report "Effects of the Atomic Bombs on Hiroshima and Nagasaki", page 16)

***PROTECTION AGAINST RADIANT HEAT.** This patient (photographed by Japanese 2 October 1945) was about 6,500 feet from ground zero when the rays struck him from the left. His cap was sufficient to protect the top of his head against flash burns.* HIROSHIMA

(Lethal 6.7 cal/sq cm, according to the 1979 US Office of Technology Assessment "Effects of Nuclear War")

AD689495 MASS BURNS

National Academy of Sciences
Washington, D.C.
1969

Dr. Edward L. Alpen (U. S. Naval Radiological Defense Laboratory): About this question of the spectral dependence of radiant energy, I think Dr. Haynes may have given you the impression that white light does the trick. There is later work which tends to refute that. The work done at Virginia used cut-off filters. The effectiveness of all energy above a certain wave length or below a certain wave length was measured. At the upper end the most effective and the least effective were mixed together and made it appear that infrared was not too good in producing burns. When you subdivide the spectrum, the most effective energy in producing a flash burn is the infrared above about 1.2 microns.

The importance of this, and the only reason I make an issue of it, is that a very important source of flash burn, both in civilian life and under wartime disaster conditions, is radiant energy burns from flaming sources. We have done a great deal of research on this subject for the U. S. Forest Service, because radiant energy burns are important in forest fires.

Energy in the wave lengths of 0.6 to 0.8 micron is about one-eighth as destructive as the rest of the spectrum. But long wave length radiation above one micron is extremely destructive, and the most effective of all.

49

Dr. Alpen: Anything that shields out radiation above one micron is extremely effective in preventing burns to the skin.

50

EFFECTS OF SPECTRAL DISTRIBUTION OF RADIANT ENERGY ON CUTANEOUS BURN PRODUCTION IN MAN AND THE RAT

Research and Development Technical Report USNRDL-TR-46

25 April 1955

by

E. L. Alpen
C.P. Butler
S.B. Martin
A.K. Davis

U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
San Francisco 24, California

For human skin the reflectivities and critical energies for production of a standard burn are the following:

filter "A", $\lambda_{max} = 0.42\mu$, $r = 24.4 \pm 3.5$ per cent, $Q = 3.20 \pm 0.37$ cal/cm^2;

filter "B", $\lambda_{max} = 0.55\mu$, $r = 40.9 \pm 3.8$ per cent, $Q = 3.25 \pm 0.28$ cal/cm^2;

filter "C", $\lambda_{max} = 0.65\mu$, $r = 56.9 \pm 2.5$ per cent, $Q = 9.9 \pm 2.1$ cal/cm^2;

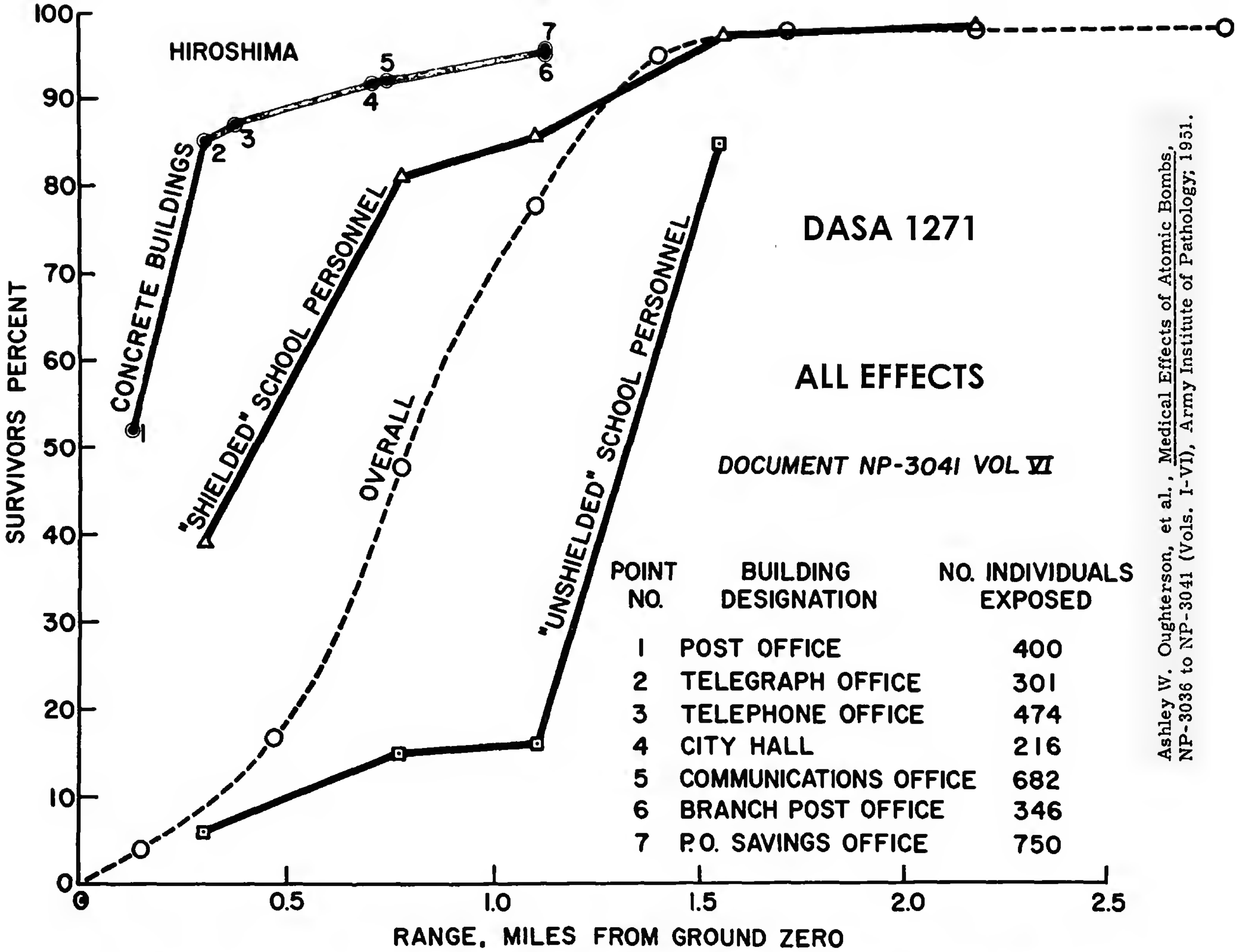
filter "D", $\lambda_{max} = 0.85\mu$, $r = 53.4 \pm 2.2$ per cent, $Q = 14.0 \pm 1.1$ cal/cm^2;

filter "F", $\lambda_{max} = 1.7\mu$, $r = 17 \pm 0.60$ per cent, $Q = 2.50$ cal/cm^2 (approx.).

The ranges shown are standard deviations.

The significance of the optical properties of skin has been discussed and the property of the high transmission of skin in the region 0.7 to 1.0 has been presented.

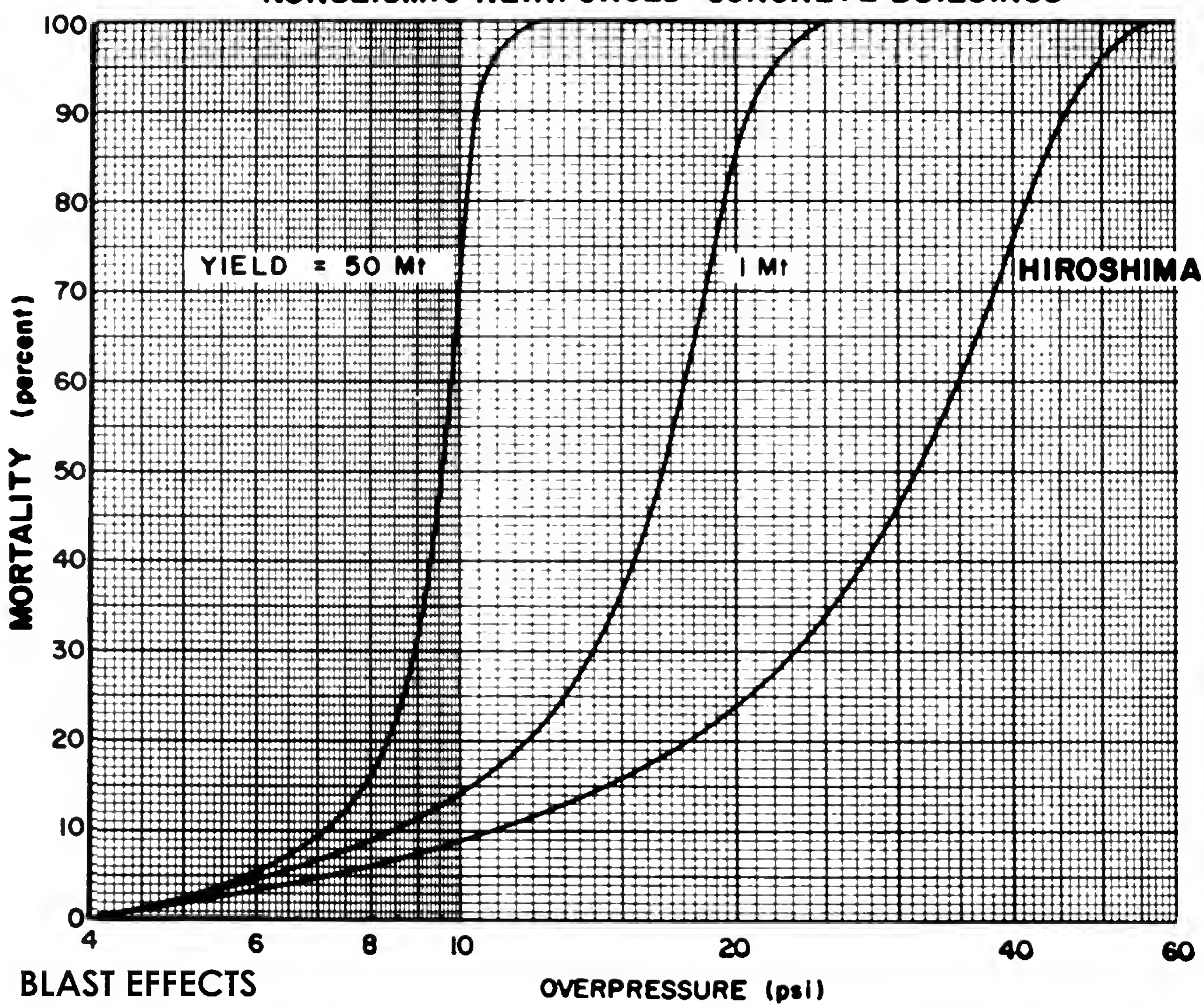
Fatsia japonica shadow on electric pole, Meiji Bridge



Ashley W. Oughterson, et al., Medical Effects of Atomic Bombs, NP-3036 to NP-3041 (Vols. I-VI), Army Institute of Pathology; 1951.

DC-P-1060

NONSEISMIC REINFORCED-CONCRETE BUILDINGS

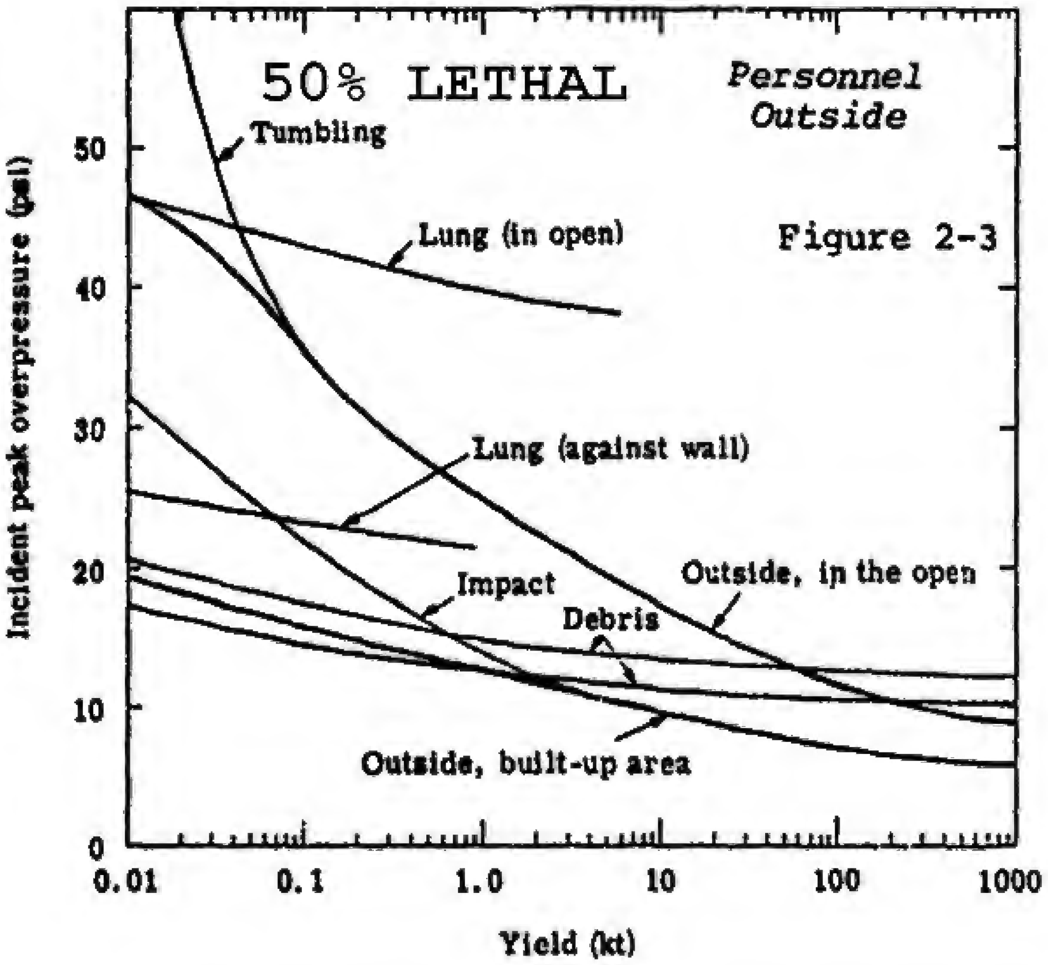


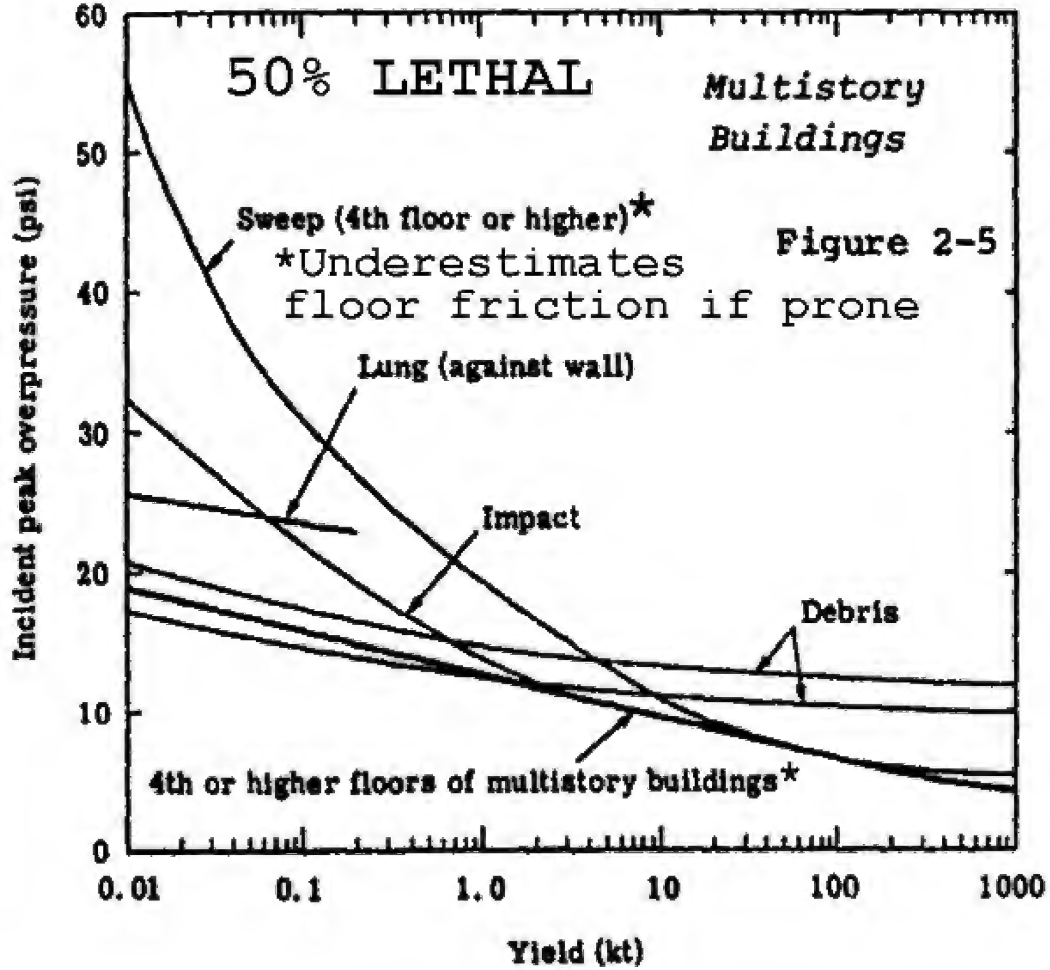
L. Wayne Davis, Donald L. Summers, William L. Baker, and James A. Keller, Prediction of Urban Casualties and the Medical Load from a High-Yield Nuclear Burst, DC-FR-1060, The Dikewood Corporation

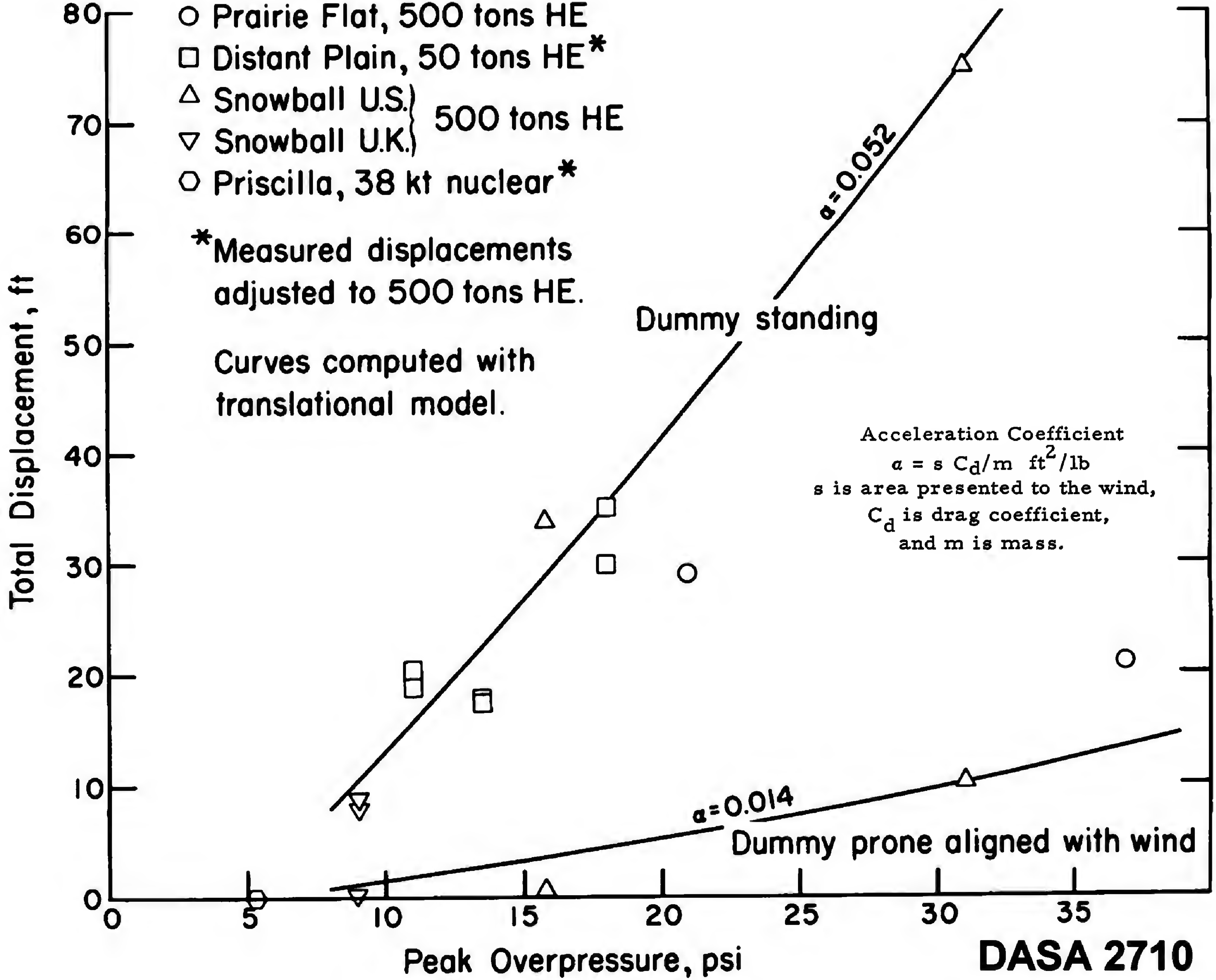
BLAST EFFECTS

USSBS Report 92, v2 Hiroshima buildings	MAE's in square miles	Radii of MAE's in feet
Multistory, earthquake-resistant	0. 03	500
Multistory, steel- and reinforced-concrete frame (including both earthquake- and non-earthquake-resistant construction)	. 05	700
1-story, light, steel-frame	3. 4	5, 500
Multistory, load-bearing, brick-wall	3. 6	5, 700
1-story, load-bearing, brick-wall	6. 0	7, 300
Wood-frame industrial-commercial (dimension-timber construction)	8. 5	8, 700
Wood-frame domestic buildings (wood-pole construction)	9. 5	9, 200
Residential construction	6. 0	7, 300

Dr Martin P. Fricke (Science Applications International Corp., California), "Preliminary Civilian Casualty Criteria for Low-Yield Nuclear Weapons," DNA-3547T, 1975.





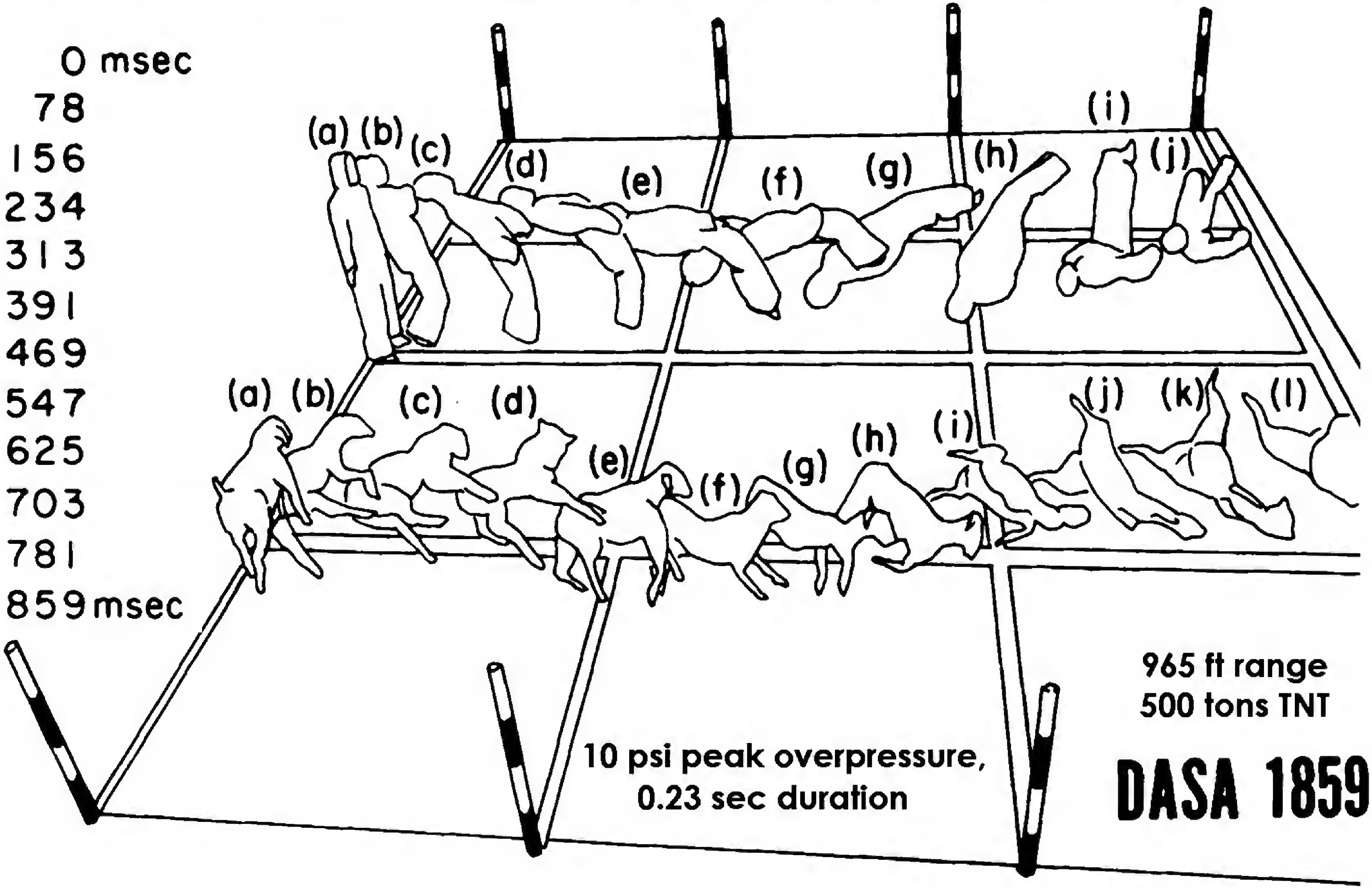


○ Prairie Flat, 500 tons HE
□ Distant Plain, 50 tons HE*
△ Snowball U.S.
▽ Snowball U.K.
500 tons HE
⬡ Priscilla, 38 kt nuclear*
*Measured displacements adjusted to 500 tons HE.
Curves computed with translational model.
α=0.052
Dummy standing
Acceleration Coefficient
α = s Cd/m ft²/lb
s is area presented to the wind,
Cd is drag coefficient,
and m is mass.
α=0.014
Dummy prone aligned with wind
Total Displacement, ft
Peak Overpressure, psi
0
10
20
30
40
50
60
70
80
0
5
10
15
20
25
30
35

DASA 2710

Operation Snowball, station 10SB, comparison of human dummy with standing goat (proxy)
peak velocity of initially standing 165 lb dummy = 33.7 ft/sec with 20 ft total displacement
(A U.K. dummy lying prone at 9 psi peak overpressure was unmoved in this test)

(a)	0 msec
(b)	78
(c)	156
(d)	234
(e)	313
(f)	391
(g)	469
(h)	547
(i)	625
(j)	703
(k)	781
(l)	859 msec



BANK OF JAPAN BUILDING AFTER ATTACK ON HIROSHIMA

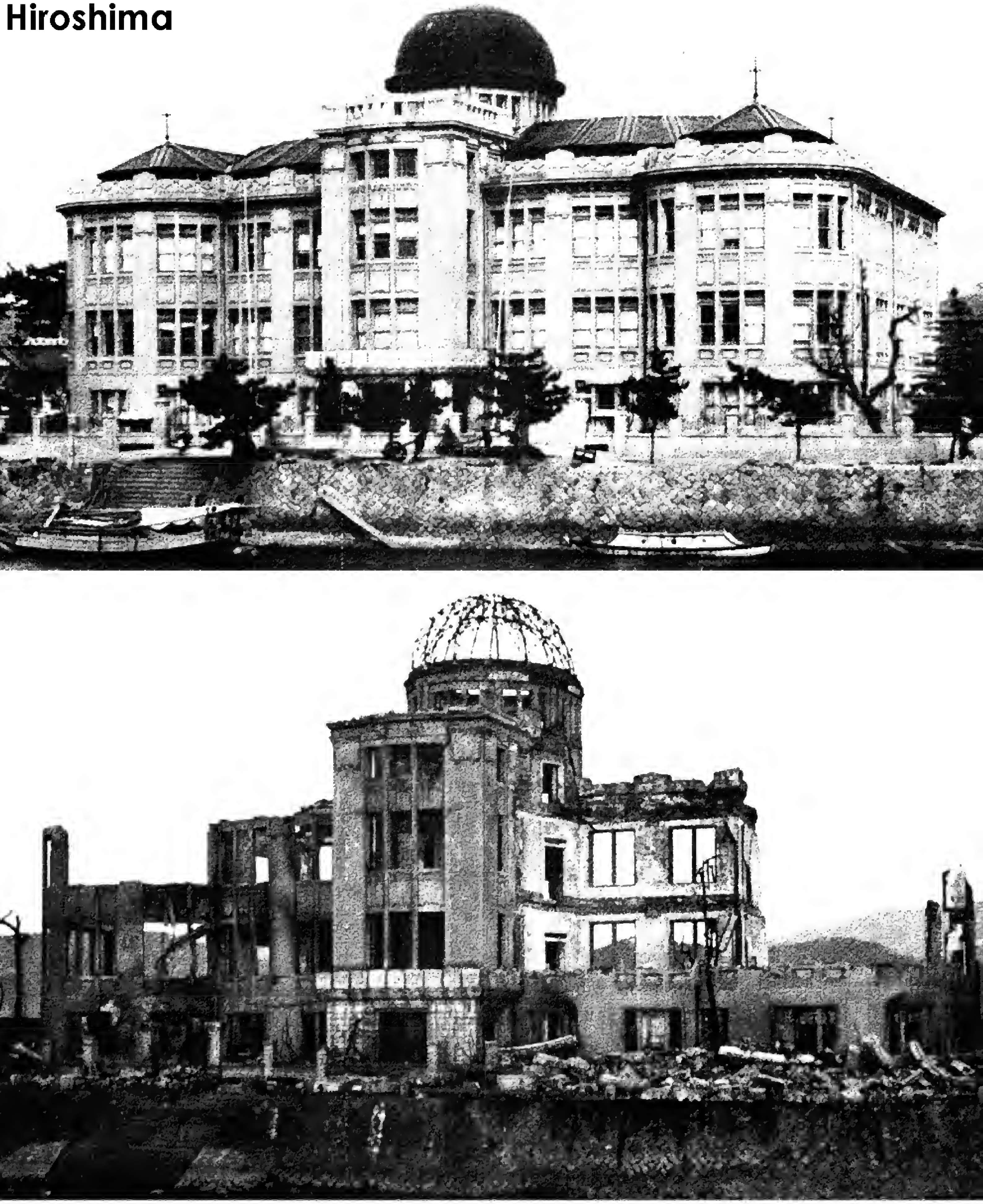
GEIBI BANK CO. BUILDING AFTER ATTACK ON HIROSHIMA

Bank of Japan: USSBS Building 24, 1300 ft from GZ
Geibi Bank Co: USSBS Building 59, 4100 ft from GZ
(Table 5 of USSBS report 92 Hiroshima, v2.)

In both, survivors extinguished fire with water buckets.

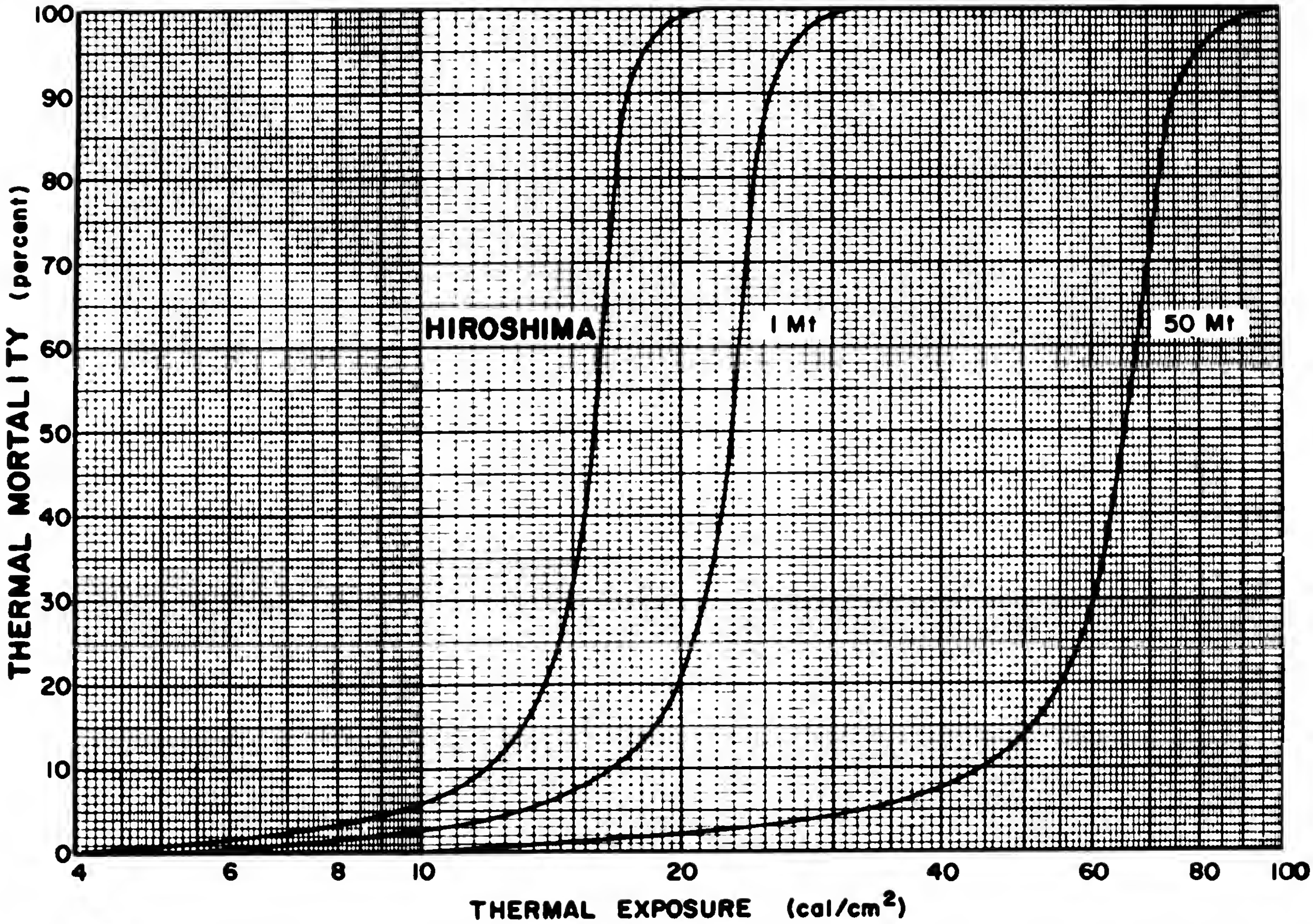
(Ref: Panel 26 of the "DCPA Attack Environment Manual", Chapter 3.)

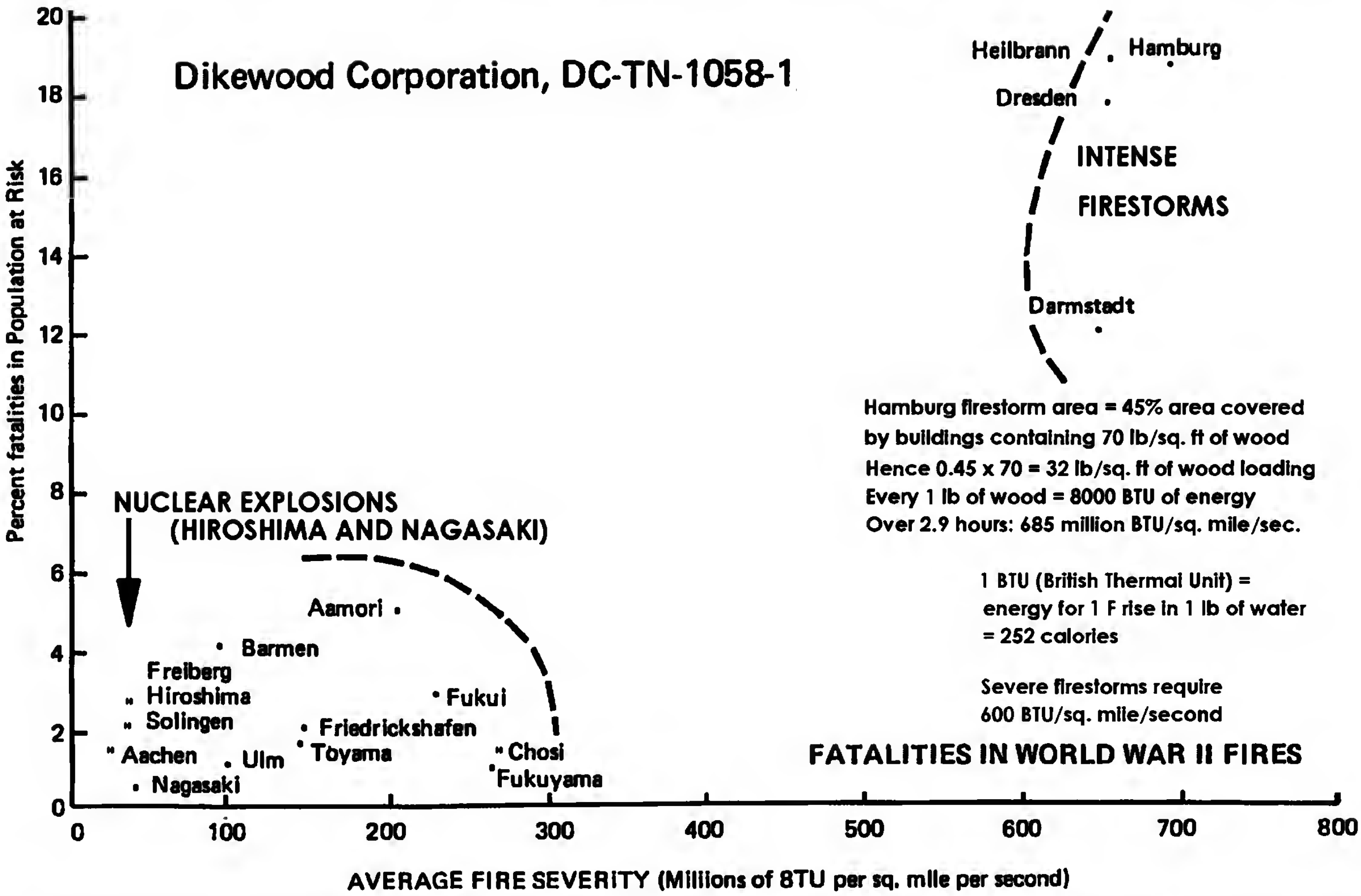
Hiroshima



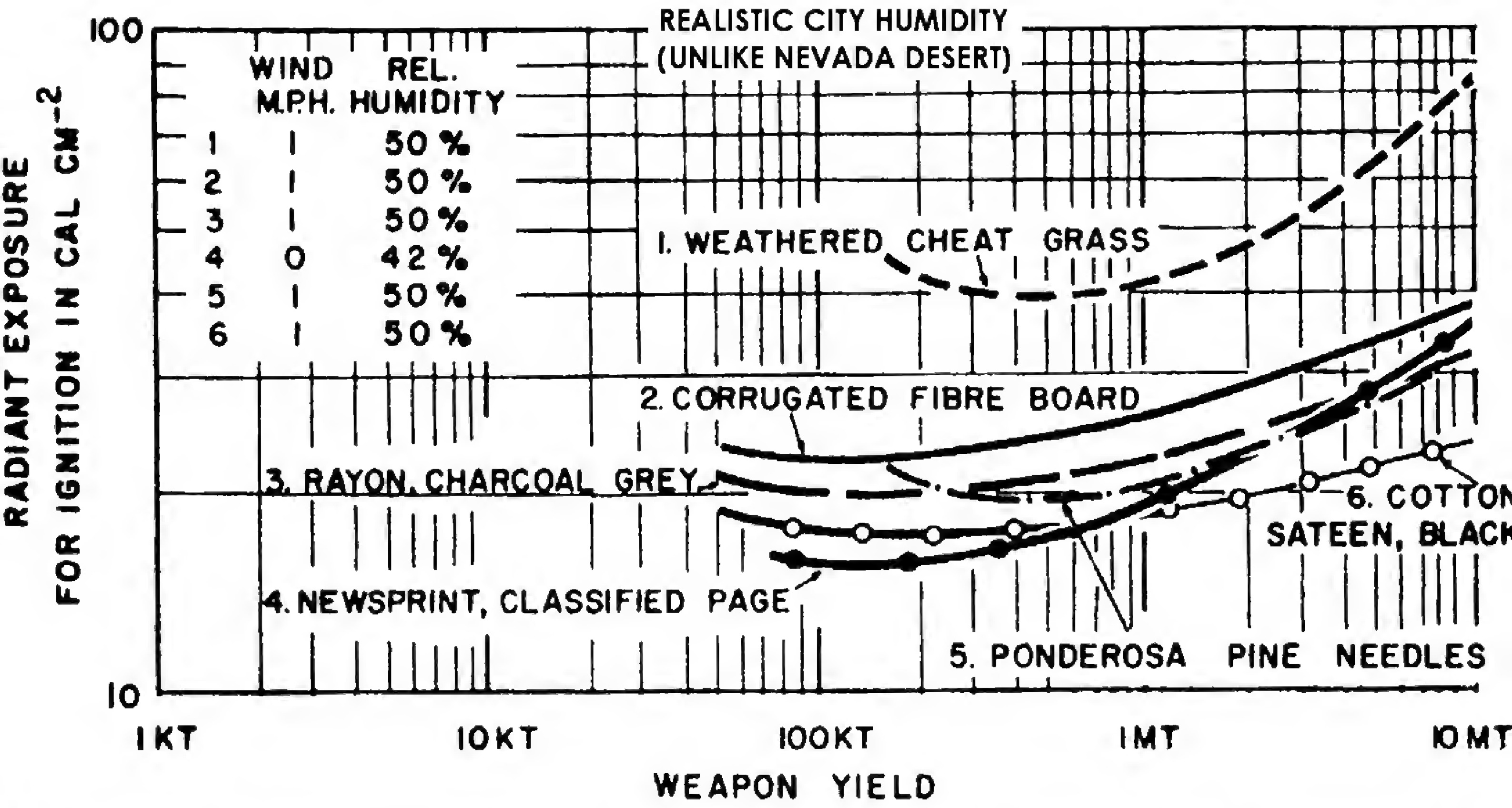
Commercial Museum (300 meters) before and after

DC-P-1060





T. E. Lommasson and J. A. Keller, A Macroscopic View of Fire Phenomenology and Mortality Prediction, Proceedings of the Tripartite Technical Cooperation Program, Mass Fire Research Symposium of the Defense Atomic Support Agency, The Dikewood Corporation; October, 1967.



"TECHNICAL OBJECTIVE AW-7, CRITICAL RADIANT EXPOSURES FOR PERSISTENT IGNITION", JULY 1960, J. BRACCIAVENTI & F. DEBOLD AD-249476; DASA-1194

UCRL-TR-231593

Thermal radiation from nuclear detonations in urban environments

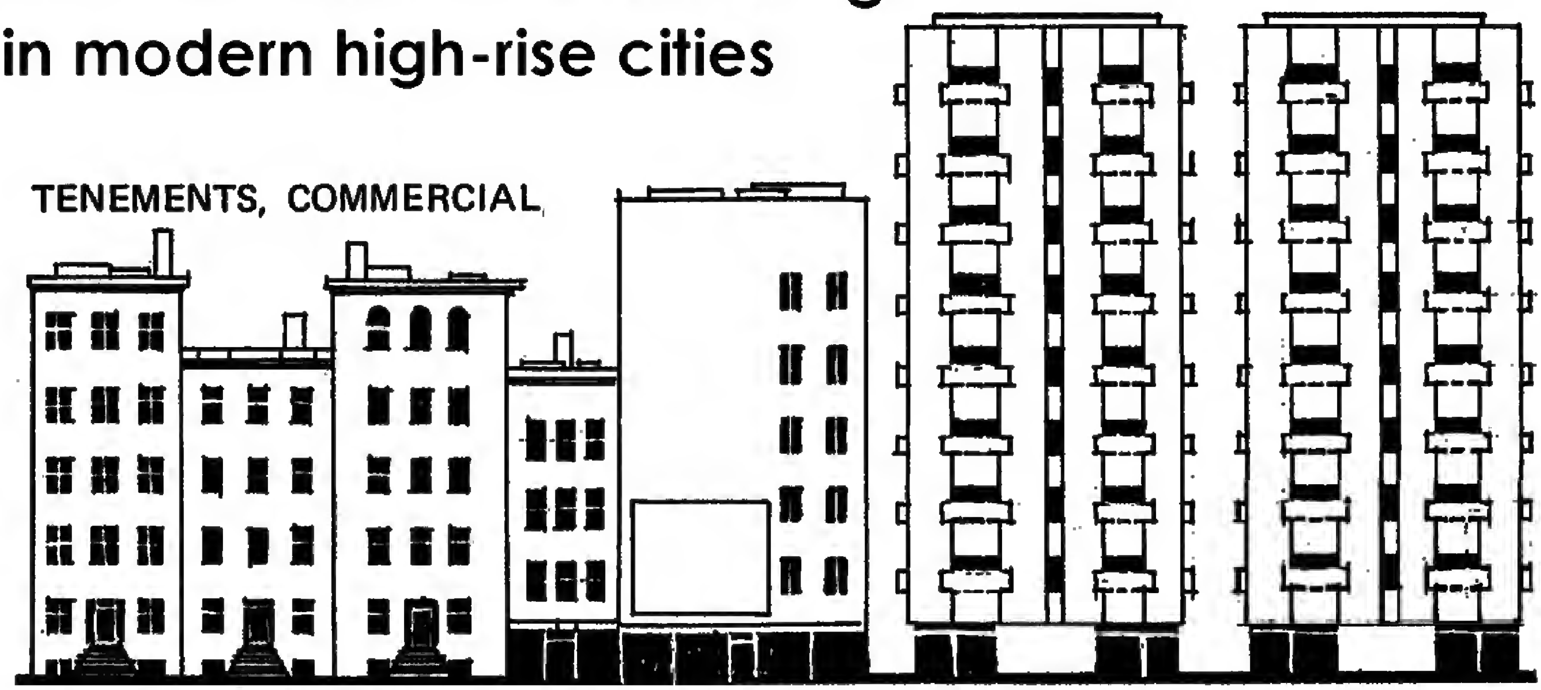
LAWRENCE LIVERMORE NATIONAL LABORATORY

June 7, 2007

Even without shadowing, the location of most of the urban population within buildings causes a substantial reduction in casualties compared to the unshielded estimates. Other investigators have estimated that the reduction in burn injuries may be greater than 90% due to shadowing and the indoor location of most of the population [6].

We have shown that common estimates of weapon effects that calculate a "radius" for thermal radiation are clearly misleading for surface bursts in urban environments. In many cases only a few unshadowed vertical surfaces, a small fraction of the area within a thermal damage radius, receive the expected heat flux.

Thermal radiation shadowing in modern high-rise cities



RESEARCH TRIANGLE INSTITUTE
Durham, North Carolina

Final Report R-85-1

CRASH CIVIL DEFENSE PROGRAM STUDY

by

K. E. Willis
E. R. Brooks
L. J. Dow

April 30, 1963

Prepared for

OFFICE OF CIVIL DEFENSE
UNITED STATES DEPARTMENT OF DEFENSE

Feasibility

In the typical household, some materials will generally be available for covering windows against thermal radiation. One half roll of aluminum foil would cover about 25 ft^2 and would provide very effective covering for 1 to 2 windows (those most likely to face the blast). Sufficient quantities of either light colored paint, Bon Ami, or whiting would be available in most households to cover windows. Aluminum screens attenuate from 30 - 50% of the thermal radiation and hence screens should be closed or installed.

The amount of water per square foot required to dissipate 25 cal/cm^2 of thermal radiation can quickly be calculated from the heat of vaporization of water (580 cal/gm). Allowing 90% losses due to absorption or spillage, one gallon of water is sufficient to wet 10 ft^2 of material so that it can withstand 25 cal/cm^2 of direct thermal radiation (i.e., the radiation is normal to the material surface at all points). Since the average daily water consumption per service (Reference 3) is about 700 gallons, it is apparent that the wetting of interior flammables (piled up curtains, furniture, etc.) is feasible in most cases when used in conjunction with the other measures.

3. Statistical Abstracts of the United States. Washington: U. S. Government Printing Office, 1962.

CIVIL DEFENCE

why we need it

Message from the Home Secretary and the Secretary of State for Scotland

For over 30 years our country, with our allies, has sought to avoid war by deterring potential aggressors. Some disagree as to the means we should use. But whatever view we take, we should surely all recognise the need – and indeed the duty – to protect our civil population if an attack were to be made upon us; and therefore to prepare accordingly.

The Government is determined that United Kingdom civil defence shall go ahead. The function of civil defence is not to encourage war, or to put an acceptable face on it. It is to adapt ourselves to the reality that we at present must live with, and to prepare ourselves so that we could alleviate the suffering which war would cause if it came.

Even the strongest supporter of unilateral disarmament can consistently give equal support to civil defence, since its purpose and effect are essentially humane.

[illegible] George Younger.

Why bother with civil defence?

Why bother with wearing a seat belt in a car? Because a seat belt is reckoned to lessen the chance of serious injury in a crash. The same applies to civil defence in peacetime.

War would be horrific. Everyone knows the kind of devastation and suffering it could cause. But while war is a possibility – however slight – it is right to take measures to help the victims of an attack, whether nuclear or 'conventional'.

But isn't it a waste of money in these days of nuclear weapons and the dreadful prospects of destruction?

No. It is money well spent if it shows people how they can safeguard themselves and their families.

But surely there is no real protection against a nuclear attack?

Millions of lives could be saved, by safeguards against radiation especially. But civil defence is not just protection against a nuclear attack. It is protection against *any* sort of attack. NATO experts reckon that any war involving the UK is likely at least to start with non-nuclear weapons. Indeed, while no war is likely so long as we maintain a credible deterrent, the likelihood of a nuclear war is less than that of a 'conventional' one.

But doesn't civil defence get people more war-minded, thus increasing the risk of conflict?

That is like saying people who wear seat belts are expecting to have more crashes than those who do not. Taking civil defence seriously means seeking to save lives in the catastrophe of an attack on our country.

To Sum Up

The case for civil defence stands regardless of whether a nuclear deterrent is necessary or not. Radioactive fallout is no respecter of neutrality. Even if the UK were not itself at war, we would be as powerless to prevent fallout from a nuclear explosion crossing the sea as was King Canute to stop the tide. This is why countries with a long tradition of neutrality (such as Switzerland and Sweden) are foremost in their civil defence precautions.

Civil defence is common sense

Further information:

Nuclear Weapons
ISBN 0 11 34055 X — HMSO £3.50 (net)

Protect and Survive
ISBN 0 11 3407289 — HMSO 50p (net)

Domestic Nuclear Shelters
ISBN 0 11 3407378 — HMSO 50p (net)

Domestic Nuclear Shelters – Technical Guidance
ISBN 0 11 34073786 — HMSO £5.50 (net)

Proceedings of the Symposium
held at Washington, D. C.
April 19-23, 1965 by the
Subcommittee on Protective Structures,
Advisory Committee on Civil Defense,
National Academy of Sciences—
National Research Council

Protective Structures

for

CIVILIAN POPULATIONS

1966

THE PROTECTION AGAINST FALLOUT RADIATION AFFORDED BY CORE SHELTERS IN A TYPICAL BRITISH HOUSE

Daniel T. Jones
Scientific Adviser, Home Office, London

Protective Factors in a Sample of British Houses (Windows Blocked)

Protective Factor	Percentage of Houses
< 25	36%
25-39	28%
40-100	29%
> 100	7%

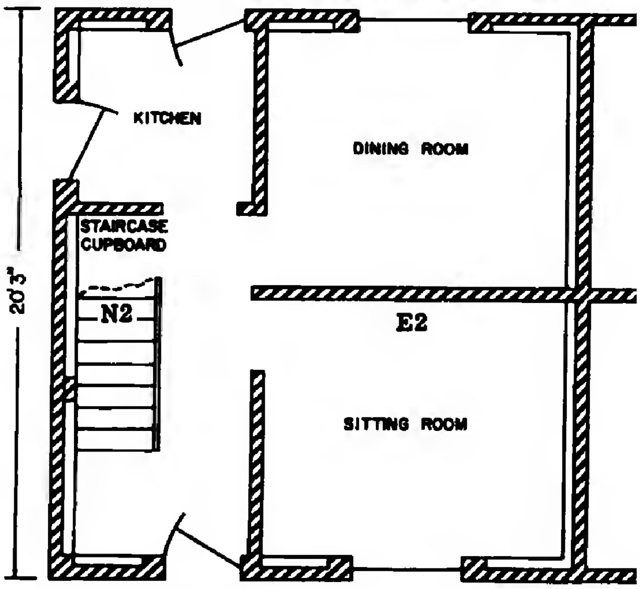
"A very much improved protection could be obtained by constructing a shelter core. This means a small, thick-walled shelter built preferably inside the fallout room itself, in which to spend the first critical hours when the radiation from fallout would be most dangerous."(1)

The full-scale experiments were carried out at the Civil Defense School at Falfield Park.(2)

In the staircase construction, the shelter consisted of the cupboard under the stairs, sandbags being placed on treads above and at the sides.

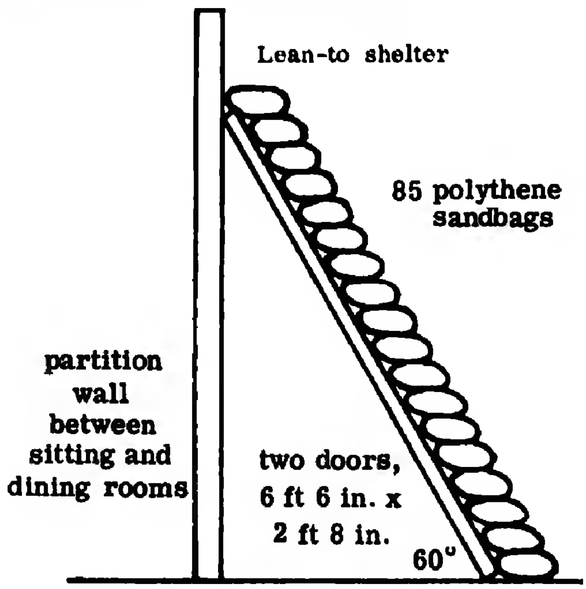
A 93 curies cobalt-60 source was used.

1. Six sandbags per tread, and a double layer on the small top landing. 96 sandbags were used.
2. As (1), together with a 4-ft-high wall of sandbags along the external north wall. 160 sandbags were used.
3. As (2), together with 4-ft-high walls of sandbags along the kitchen/cupboard partition wall and along the passage partition. 220 sandbags were used.



sandbags 24 in. x 12 in. when empty; 16 in. x 9 in. x 4 in. when filled with 25 lb of sand.

9 in. brick walls The windows and doors were not blocked		contribution r/hr/c/ft^2		Protective Factor
	Position	Ground	Roof	
House only	E2	15.0	8.4	21
Lean-to	E2	10.4	2.4	39
Staircase cupboard:				
Stairs only sandbagged	N2	29.2	5.3	14
Stairs and outer wall sandbagged	N2	16.4	4.6	24
Stairs, outer wall, kitchen wall and corridor partition sandbagged	N2	8.8	1.8	47



floor area 21 sq ft.

1. Civil Defence Handbook No. 10, HMSO, 1963.
2. Perryman, A. D., Home Office Report CD/SA 117.

BLAST AND OTHER THREATS

Harold Brode
The RAND Corporation, Santa Monica, California

Chemical High-Explosive Weapons

As in past aerial warfare, bombs and missiles carrying chemical explosives to targets are capable of extensive damage only when delivered in large numbers and with high accuracy.

Biological Warfare

Most biological agents are inexpensive to produce; their effective dissemination over hostile territories remains the chief deterrent to their effective employment. Twenty square miles is about the area that can be effectively covered by a single aircraft; large area coverage presents a task for vast fleets of fairly vulnerable planes flying tight patterns at modest or low altitudes. While agents vary in virulence and in their biologic decay rate, most are quite perishable in normal open-air environments. Since shelter and simple prophylactic measures can be quite effective against biological agents, there is less likelihood of the use of biological warfare on a wholesale basis against a nation, and more chance of limited employment on population concentrations —perhaps by covert delivery, since shelters with adequate filtering could insure rather complete protection to those inside.

Chemical Weapons

Chemical weapons, like biological weapons, are relatively inexpensive to create, but face nearly insurmountable logistics problems on delivery. Although chemical agents produce casualties more rapidly, the greater amounts of material to deliver seriously limit the likelihood of their large-scale deployment. Furthermore, chemical research does not hold promise of the development of significantly more toxic chemicals for future use.

Radiological Weapons

The advantages of such modifications are much less real than apparent. In all weapons delivered by missiles, minimizing the payload and total weight is very important. If the total payload is not to be increased, then the inclusion of inert material to be activated by neutrons must lead to reductions in the explosive yield. If all the weight is devoted to nuclear explosives, then more fission-fragment activity can be created, and it is the net difference in activity that must be balanced against the loss of explosive yield. As it turns out, a fission explosion is a most efficient generator of activity, and greater total doses are not achieved by injecting special inert materials to be activated.

The Neutron Bomb

The neutron bomb, so called because of the deliberate effort to maximize the effectiveness of the neutrons, would necessarily be limited to rather small yields—yields at which the neutron absorption in air does not reduce the doses to a point at which blast and thermal effects are dominant. The use of small yields against large-area targets again runs into the delivery problems faced by chemical agents and explosives, and larger yields in fewer packages pose a less stringent problem for delivery systems in most applications. In the unlikely event that an enemy desired to minimize blast and thermal damage and to create little local fallout but still kill the populace, it would be necessary to use large numbers of carefully placed neutron-producing weapons burst high enough to avoid blast damage on the ground, but low enough to get the neutrons down. In this case, however, adequate radiation shielding for the people would leave the city unscathed and demonstrate the attack to be futile.

The thermal radiation from a surface burst is expected to be less than half of that from an air burst, both because the radiating fireball surface is truncated and because the hot interior is partially quenched by the megatons of injected crater material.

SUPERSEISMIC GROUND-SHOCK MAXIMA (AT 5-FT DEPTH)

Vertical acceleration: $\alpha_{vm} \simeq 340\,\Delta P_s/C_L \pm 30$ per cent. Here acceleration is measured in g's and overpressure (ΔP_s) in pounds per square inch. An empirical refinement requires C_L to be defined as the seismic velocity (in feet per second) for rock, but as three fourths of the seismic velocity for soil.

OUTRUNNING GROUND-SHOCK MAXIMA (AT ~10-FT DEPTH)

Vertical acceleration: $\alpha_{vm} \simeq 2 \times 10^5/C_L r^2$ + factor 4 or -factor 2. Acceleration is measured in g's, and r is the scaled radial distance—i.e., $r = R/W^{1/3}$ kft/(mt)$^{1/3}$.

Data taken on a low air-burst shot in Nevada indicate an exponential decay of maximum displacement with depth. For the particular case of a burst of ~ 40 kt at 700 ft, some measurements were made as deep as 200 ft below the surface of Frenchman Flat, a dry lake bed, which led to the following approximate decay law, according to Perret.

$\delta = \delta_0 \exp(-0.017D)$,

where δ represents the maximum vertical displacement induced at depth D, δ_0 is the maximum displacement at the surface, and D is the depth in feet.

Perret, W.R., Ground Motion Studies at High Incident Overpressure, The Sandia Corporation, Operation PLUMBBOB, WT-1405, for Defense Atomic Support Agency Field Command, June 1960.

MODEL ANALYSIS

Mr. Ivor Ll. DAVIES
Suffield Experimental Station
Canadian Defense Research Board
Ralston, Alberta, Canada

Nuclear-Weapon Tests

In 1952 we fired our first nuclear device, effectively a "nominal" weapon, at Monte Bello, off northwest Australia. To the blast loading from this weapon we exposed a number of reinforced-concrete cubicle structures that had been designed for the dynamic loading conditions, and for which we made the best analysis of response we were competent to make at that time. Our estimates of effects were really a dismal failure. The structures were placed at pressure levels of 30, 10, and 6 psi, where we expected them to be destroyed, heavily damaged with some petaling of the front face, and extensively cracked, respectively. In fact, the front face of the cubicle at 30 psi was broken inwards; failure had occurred along both diagonals, and the four triangular petals had been pushed in. At the 10-psi level, where we had three cubicles, each with a different wall thickness (6, 9, and 12 in.), we observed only light cracking in the front face of that cubicle with the least thick wall (6 in.). The other two structures were apparently undamaged, as was the single structure at the 6-psi level.

In 1957, the first proposals were made for the construction of the underground car park in Hyde Park in London. The Home Office was interested in this project since, in an emergency, the structure could be used as a shelter. Consequently a request was made to us at Atomic Weapons Research Establishment (A.W.R.E.) to design a structure that would be resistant to a blast loading of about 50 psi, and to test our design on the model scale.

Using the various load-deformation curves obtained in this test, an estimate was made of the response of the structure to blast loading. Of particular interest was the possible effect of 100 tons of TNT, the first 100-ton trial at Suffield in Alberta.

10 p.s.i.

34 p.s.i.

Dynamic tests, Monte Bello cubicles.

A total of seven more models was made; six were shipped to Canada and placed with the top surface of the roof flush with the ground and at positions where peak pressures of 100, 80, 70, 60, 50, and 40 psi were expected. The seventh model was kept in England for static testing at about the time of firing. The results were not as expected. In the field, the four models farthest from the charge were apparantly undamaged; we could see no cracking with the eye, nor did soaking the models with water reveal more than a few hair cracks. The model nearest the charge was lightly cracked in the roof panels and beams, and one of the columns showed slight spalling at the head. This model had been exposed to a peak pressure of 110 psi.

Davies, I. Ll., Effects of Blast on Reinforced Concrete Slabs, and the Relationship with Static Loading Characteristics (U). United Kingdom, Operation BUFFALO - Target Response Tests, AWRE Report T 46/57 (CONFIDENTIAL report), August 1957.

Wood, A. J., The Effect of Earth Covers on the Resistance of Trench Shelter Roofs (U). United Kingdom, Operation BUFFALO-Target Response Target Response Tests, AWRE Report T 47/57 (CONFIDENTIAL report), August 1957.

O'Brien, T. P., Rowe, R. D., and Hance, R. J., The Effect of Atomic Blast on Wall Panels (U). United Kingdom, FWE-36 (CONFIDENTIAL report), April 1955.

Walley, F., Operation TOTEM Group 13 Report: Civil Defense Structures (U). United Kingdom, FWE-111 (CONFIDENTIAL report), May 1957.

Davies, I. Ll., and Thumpston, N. S., The Resistance of Civil Defense Shelters to Atomic Blast (U). United Kingdom, FWE 35 (UNCLASSIFIED report), March 1955.

Davies, I. Ll., The Resistance of Civil Defense Shelters to Atomic Blast: IV Final Report on Experiments with Reinforced Models of Heavily Protective Citadel Shelter Type CD12 (U). United Kingdom, FWE-101 (CONFIDENTIAL report), May 1958.

Davies, I. Ll., Performance Test on Model Garage - Shelter Roof System. SES 100 Ton TNT Trial-Suffield, Alberta, August 1961 (U). United Kingdom, AWRE Report No. E 2/63 (FOR OFFICIAL USE ONLY), March 1963.

Worsfold, W. E., Effects of Shielding a Building from Atomic Blast (U). United Kingdom, FWE-164 (CONFIDENTIAL report), August 1958.

Trimer, A., and Maskell, E. G. B., Operation BUFFALO Target Response Tests - Structures Group Report: The Effect on Field Defenses (U). United Kingdom, FWE-241 (CONFIDENTIAL report), December 1959.

United Kingdom, The Effects of Atomic Weapons on Structures and Military Equipment (U). FWE-8 (SECRET report), July 1954.

Foreword

If the country were ever faced with an immediate threat of nuclear war, a copy of this booklet would be distributed to every household as part of a public information campaign which would include announcements on television and radio and in the press. The booklet has been designed for free and general distribution in that event. It is being placed on sale now for those who wish to know what they would be advised to do at such a time.

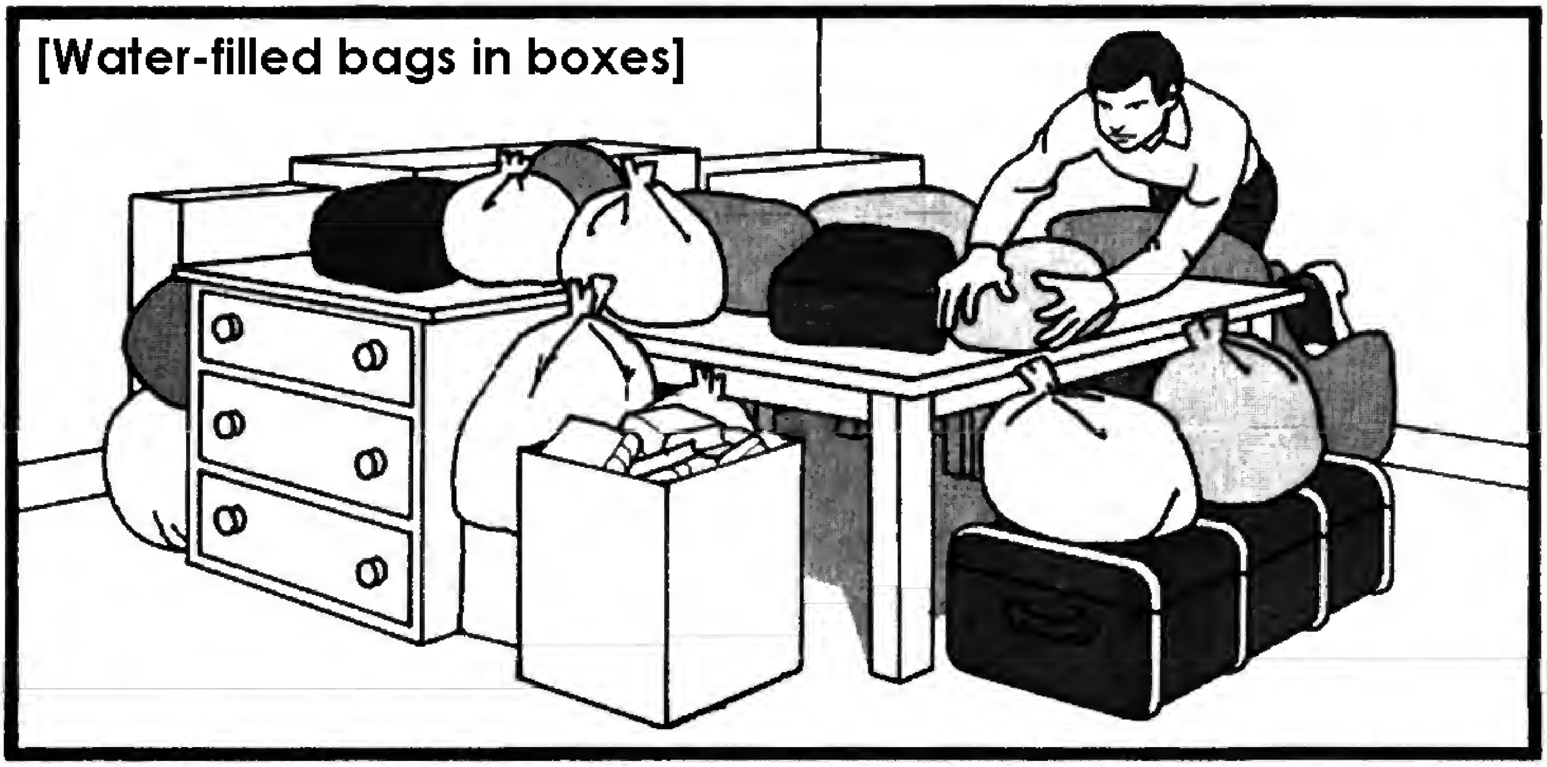
May 1980

Protect and Survive
ISBN 0 11 3407289

If Britain is attacked by nuclear bombs or by missiles, we do not know what targets will be chosen or how severe the assault will be.

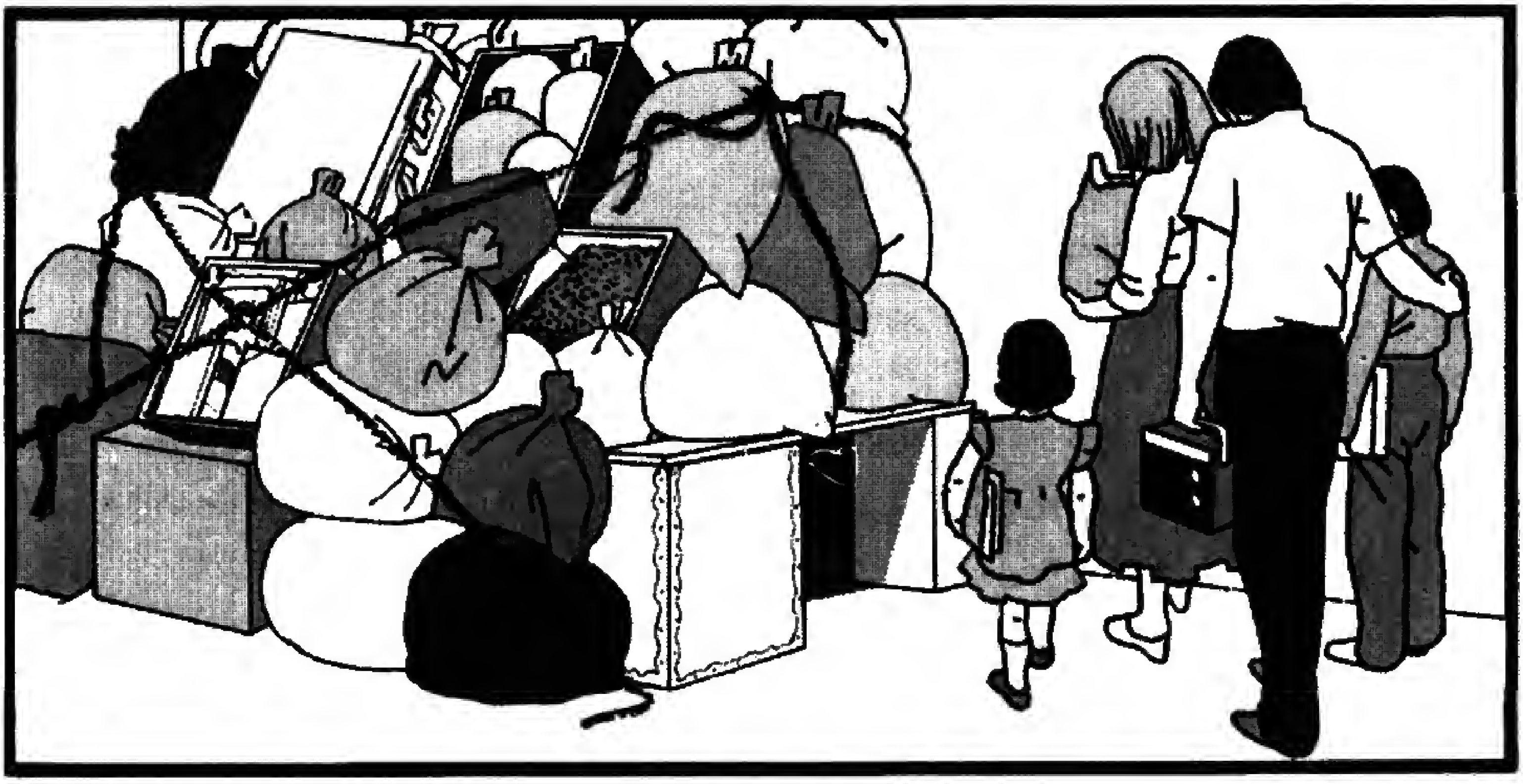
If nuclear weapons are used on a large scale, those of us living in the country areas might be exposed to as great a risk as those in the towns. The radioactive dust, falling where the wind blows it, will bring the most widespread dangers of all. No part of the United Kingdom can be considered safe from both the direct effects of the weapons and the resultant fall-out.

The dangers which you and your family will face in this situation can be reduced if you do as this booklet describes.



If there is structural damage from the attack you may have some time before a fall-out warning to do minor jobs to keep out the weather – using curtains or sheets to cover broken windows or holes.

If you are out of doors, take the nearest and best available cover as quickly as possible, wiping all the dust you can from your skin and clothing at the entrance to the building in which you shelter.



HOME OFFICE

CIVIL DEFENCE

Manual of Basic Training

VOLUME II

BASIC METHODS OF PROTECTION AGAINST HIGH EXPLOSIVE MISSILES

PAMPHLET No 5

LONDON: HIS MAJESTY'S STATIONERY OFFICE
1949

SIXPENCE NET

Domestic Shelters (for household use)

(*a*) ANDERSON SHELTER. This shelter was designed for erection outside the house. It consisted of 14 gauge corrugated steel sheets, steel angles, ties and channel irons. It was normally sunk about 3 ft. into the ground and covered over with earth to a minimum depth of 15 in., which, with the 14 gauge corrugated sheet gives the equivalent of 18 in. of earth.

The standard shelter was 6 ft. 6 in. by 4 ft. 6 in. by 6 ft. high. It was designed to shelter six persons, but was capable of being lengthened to accommodate eight, ten or twelve persons; or of being shortened to accommodate four persons.

Unless the entrance was screened (within 15 ft.) by a building or existing wall, a screen wall had to be provided. Trouble was sometimes experienced due to flooding by subsoil water in which case the below ground portion was tanked by a lining of cement concrete.

The shelter was, on occasions, erected on the surface, which involved casing it in cement concrete. The result was efficient but expensive.

(*b*) MORRISON SHELTER. This shelter was designed for use in a house and its chief function was to protect the occupants from being crushed by the collapse of the building. Protection against blast and fragments was provided by the walls of the house, which were sometimes specially thickened for this purpose.

It consisted of a steel table measuring 6 ft. 4 in. long by 3 ft. 10½ in. wide. It provided sleeping accommodation for two adults and a child, or a considerable number of small children in a sitting position, when used as a school classroom shelter.

(*c*) STRUTTED REFUGE ROOM—STRUTTED BASEMENT. The object of this form of shelter was the same as the Morrison shelter, i.e. to provide strutting to prevent the collapse of the room and to use the walls as protection against blast and fragments. Strutting was either steel or wood and the design and strength suited to the weight to be supported.

(*d*) SMALL TRENCH OR SMALL SURFACE SHELTER IN GARDEN. This type of shelter needs no special comment.

DNA EM-1
PART I

DEFENSE NUCLEAR AGENCY EFFECTS MANUAL NUMBER 1

CAPABILITIES OF NUCLEAR WEAPONS

1 JULY 1972

HEADQUARTERS
Defense Nuclear Agency
Washington, D.C. 20305

DNA EM-1
PART I
CHANGE 2
1 AUGUST 1981

DEFENSE NUCLEAR AGENCY EFFECTS MANUAL NUMBER 1

CAPABILITIES OF NUCLEAR WEAPONS

PART I
PHENOMENOLOGY

HEADQUARTERS
Defense Nuclear Agency
Washington, D.C. 20305

EDITOR
PHILIP J. DOLAN
SRI INTERNATIONAL

FOREWORD

This edition of the *Capabilities of Nuclear Weapons* represents the continuing efforts by the Defense Nuclear Agency to correlate and make available nuclear weapons effects information obtained from nuclear weapons testing, small-scale experiments, laboratory effort and theoretical analysis. This document presents the phenomena and effects of a nuclear detonation and relates weapons effects manifestations in terms of damage to targets of military interest. It provides the source material and references needed for the preparation of operational and employment manuals by the Military Services.

The *Capabilities of Nuclear Weapons* is not intended to be used as an employment or design manual by itself, since more complete descriptions of phenomenological details should be obtained from the noted references. Every effort has been made to include the most current reliable data available on 31 December 1971 in order to assist the Armed Forces in meeting their particular requirements for operational and target analysis purposes.

Comments concerning this manual are invited and should be addressed:

Director
Defense Nuclear Agency
ATTN: STAP
Washington, D. C. 20305

C. H. DUNN
Lt General, USA
Director

[redacted]

Shielding is most effective when the obstacle is between the target and ground zero.

[redacted] Obstacles that are considered in the asses[redacted]ent of the effects of shielding from air blast are local obstacles, such as ravines, constructed slots, or revetments (the effects of large terrain features on blast waves are discussed in paragraphs 2-38 through 2-41 of Chapter 2). The importance of shielding is well documented. Comparisons of damage between shielded and unshielded vehicles exposed to blast from both nuclear and chemical explosions are available. The effectiveness of an obstacle in shielding a target generally results as much from its capability to reduce the target movement as from its ability to modify the blast environment. Figure 14-8 illustrates this point. When the obstacle is between the blast wave and the target most of the impulse or translational force that induces motion (drag loading) does not act on the target. When the obstacle is "behind" the target, the translational force initially applied to the target is the same as it would have been without an obstacle, but the obstacle not only can modify later translational forces (as a result of shock wave reflection), but it can restrict movement, the major cause of damage. The overpressure effects of crushing and fracturing still occur in both cases, and these effects provide lower limits for damage ground distances.

[redacted] Most damage resulting from low yield weapons is caused by overpressure impulse rather than translation, even for unshielded targets, and, since overpressure impulse is not altered drastically by shielding, the effects of shielding are relatively minor for such weapons. However, most damage caused to non-shielded targets by higher yield weapons results from the translational effects of dynamic pressure. Since shielding can reduce translational effects substantially, it can be quite effective as a protection from large yield weapons. Damage to shielded targets results largely from overpressure effects, for which damage distances scale as the cube root of the yield ($W^{1/3}$), while damage to unshielded targets results largely from total impulse effects (including those of dynamic pressure), for which damage distances generally scale as $W^{0.4}$. The effects of shielding are illustrated in Figure 14-9, in which damage distances for shielded targets have been scaled as $W^{1/3}$, and those for unshielded targets by $W^{0.4}$.

14-5 Effects of Ground Surface Conditions [redacted]

[redacted] Ground surface conditions affect damage in two ways: by modification of the blast parameters; and by modification of target response.

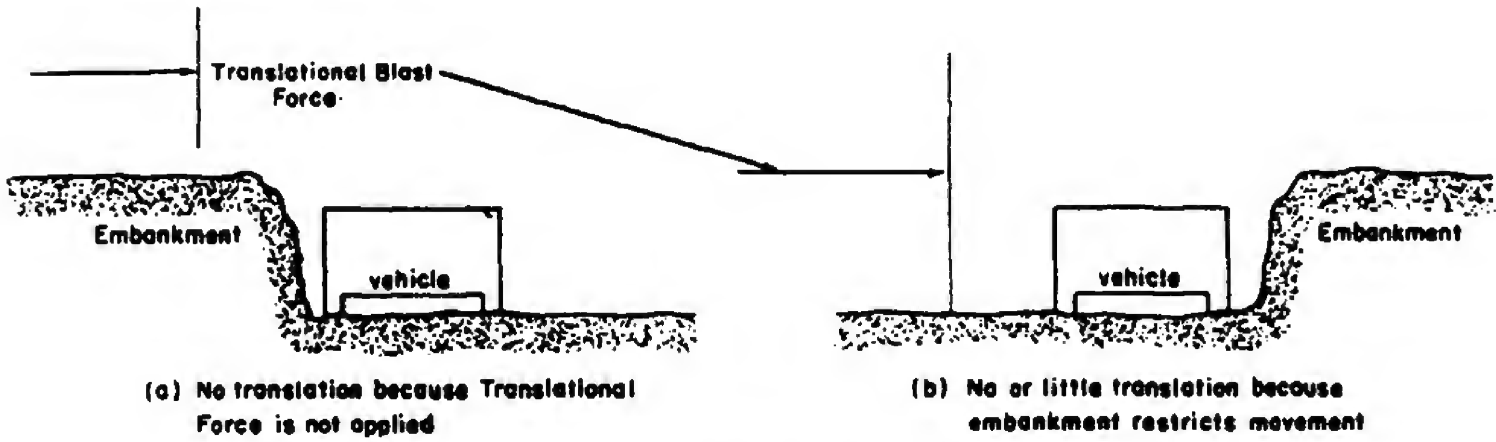


Figure 14-8. [redacted] The Effect of Shielding [redacted]

A parameter that is useful for calculating thermal response of materials is the characteristic thermal response time τ_o, given by the equation

$$\tau_o = \rho C_p L^2/k \text{ sec},$$

where k is thermal conductivity (cal-sec^{-1} cm^{-1}°C^{-1}), ρC_p is heat capacity per unit volume (ρ = density in g-cm^{-3} and C_p = specific heat at constant pressure in cal-g^{-1}°C^{-1}), and L is the thickness, in centimeters, of the layer of material.

The quantity

$$\alpha = \frac{k}{\rho C_p}$$

is called thermal diffusivity (cm^2/sec). Use of this quantity simplies the previous equation to

$$\tau_o = \frac{L^2}{\alpha} \text{ sec.*}$$

For any particular material exposed to a rectangular pulse of length τ, the previous equation can be transformed to give a characteristic thickness

$$\delta = \sqrt{\alpha\tau} \text{ cm},$$

for which the characteristic time is equal to the pulse duration. If a thick slab of this material is exposed to a pulse of length τ, the temperature rise at the surface is the same as would be produced by uniformly distributing the absorbed thermal energy in a slab of thickness δ, and the peak temperature rise at depth δ in the thick slab is about half as great as the peak temperature rise at the surface.

For example, consider a block of red pine that is exposed to 15 cal/cm^2 from a rectangular pulse of 3 seconds duration. From Table 9-1,

$$\delta = \sqrt{\alpha\tau} = \sqrt{(24 \times 10^{-3})(3)} = 0.085 \text{ cm}.$$

* This equation is useful, but it is by no means exact. The simplified heat-flow analysis from which this equation is derived neglects the effects of radiation and convection heat losses from the surfaces of the exposed sample. It also assumes an isotropic medium, i.e., a medium whose structure and properties in the neighborhood of any point are the same relative to all directions through the point. It also neglects the changes in thermal properties that occur as the exposed material heats, volatilizes, chars, and bursts into flame.

The heat absorbed by the wood before it begins to scorch is equal to the product of the incident radiant energy, Q, and the absorption coefficient, A.

$$\Delta T_s = \frac{QA}{\rho\delta C_p} = \frac{QA}{\rho C_p \sqrt{\alpha\tau}} = \frac{QA}{\rho C_p \sqrt{\tau k/\rho C_p}},$$

where ΔT_s is the peak temperature rise at the surface. The parameters that define the thermal pulse may be separated from those that define the material properties, and

$$\Delta T_s = \left(\frac{Q}{\sqrt{\tau}}\right)\left(\frac{A}{\sqrt{k\rho C_p}}\right).$$

For a fixed rectangular pulse, $Q/\sqrt{\tau}$ is a constant, and the equation may be written

$$\Delta T_s = (K)\left(\frac{A}{\sqrt{k\rho C_p}}\right).$$

Sustained ignition only occurs when higher radiant exposures raise the temperature throughout the thickness of the cellulose to a level that is sufficiently high to sustain the flow of combustible gases from breakdown of the fuel. It is difficult to supply sufficient energy with short pulses, since a large amount of the energy that is deposited is carried away by the rapid ablation of the thin surface layer. This transient flaming phenomenon is typical of the response of sound wooden boards to a thermal pulse.

Table 9-1. [redacted] Thermal Properties of Materials [redacted]

Materials	Density, ρ (gm/cm^3)	Specific Heat, C_p ($cal/gm \cdot {}^\circ C$)	Conductivity, k ($cal/sec \cdot cm \cdot {}^\circ C$)	Diffusivity, α (cm^2/sec)
Insulating Materials				
Air	9.46×10^{-4}	0.24	0.55×10^{-4}	0.22
Asbestos	0.58	0.20	4.6×10^{-4}	$40. \times 10^{-4}$
Balsa	0.12	0.4	1.2×10^{-4}	$25. \times 10^{-4}$
Brick (common red)	1.8	0.2	$16. \times 10^{-4}$	$18. \times 10^{-4}$
Celluloid	1.4	0.35	5.0×10^{-4}	$10. \times 10^{-4}$
Cotton, sateen, green	0.70	0.35	1.5×10^{-4}	2.5×10^{-4}
Fir, Douglas-				
spring growth	0.29	0.4	$2. \times 10^{-4}$	$17. \times 10^{-4}$
summer growth	1.00	0.4	$5. \times 10^{-4}$	$12. \times 10^{-4}$
Fir, white	0.45	0.4	2.6×10^{-4}	$14. \times 10^{-4}$
Glass, window	2.2	0.2	$19. \times 10^{-4}$	$43. \times 10^{-4}$
Granite	2.5	0.19	$66. \times 10^{-4}$	$140. \times 10^{-4}$
Leather sole	1.0	0.36	3.8×10^{-4}	$11. \times 10^{-4}$
Mahogany	0.53	0.36	3.1×10^{-4}	$16. \times 10^{-4}$
Maple	0.72	0.4	4.5×10^{-4}	$16. \times 10^{-4}$
Oak	0.82	0.4	5.0×10^{-4}	$15. \times 10^{-4}$
Pine, white	0.54	0.33	3.6×10^{-4}	$18. \times 10^{-4}$
Pine, red	0.51	0.4	$5. \times 10^{-4}$	$24. \times 10^{-4}$
Rubber, hard	1.2	0.5	3.6×10^{-4}	$60. \times 10^{-4}$
Teak	0.64	0.4	4.1×10^{-4}	$16. \times 10^{-4}$
Metals (100°C)				
Aluminum	2.7	0.22	0.49	1.0
Cadmium	8.65	0.057	0.20	0.45
Copper	8.92	0.094	0.92	1.1
Gold	19.3	0.031	0.75	1.2
Lead	11.34	0.031	0.081	0.23
Magnesium	1.74	0.25	0.38	0.87
Platinum	21.45	0.027	0.17	0.29
Silver	10.5	0.056	0.96	1.6
Steel, mild	7.8	0.11	0.107	1.2
Tin	6.55	0.056	0.14	0.38
Miscellaneous Materials				
Ice (0°C)	0.92	0.492	$54. \times 10^{-4}$	$120. \times 10^{-4}$
Water	1.00	1.00	$14. \times 10^{-4}$	$14. \times 10^{-4}$
Skin (porcine, dermis, dead)	1.06	0.77	$9. \times 10^{-4}$	$11. \times 10^{-4}$
Skin (human, living, averaged for upper 0.1 cm)	1.06	0.75	$8. \times 10^{-4}$	$30. \times 10^{-4}$
Polyethylene (black)	0.92	0.55	$8. \times 10^{-4}$	$17. \times 10^{-4}$

If the pulse is of long duration, the ignition threshold rises because the exposed material can dissipate an appreciable fraction of the energy while it is being received. For very long rectangular pulses an irradiance of about 0.5 cal · $cm^{-2} sec^{-1}$ is required to ignite the cellulose. Heat supplied to the material at a slow rate is just sufficient to offset radiative and convective heat losses, while maintaining the cellulose at the ignition temperature of about 300°C.

9-19

Most thick, dense materials that ordinarily are considered inflammable do not ignite to persistent flaming ignition when exposed to transient thermal radiation pulses. Wood, in the form of siding or beams, may flame during the exposure but the flame is extinguished when the exposure ceases.

9-25

DEPARTMENT OF THE ARMY FIELD MANUAL

MARINE CORPS FLEET MARINE FORCE MANUAL

FM 101-31-1
FMFM 11-4

STAFF OFFICERS' FIELD MANUAL NUCLEAR WEAPONS EMPLOYMENT DOCTRINE AND PROCEDURES

DEPARTMENTS OF THE ARMY AND THE NAVY
FEBRUARY 1968

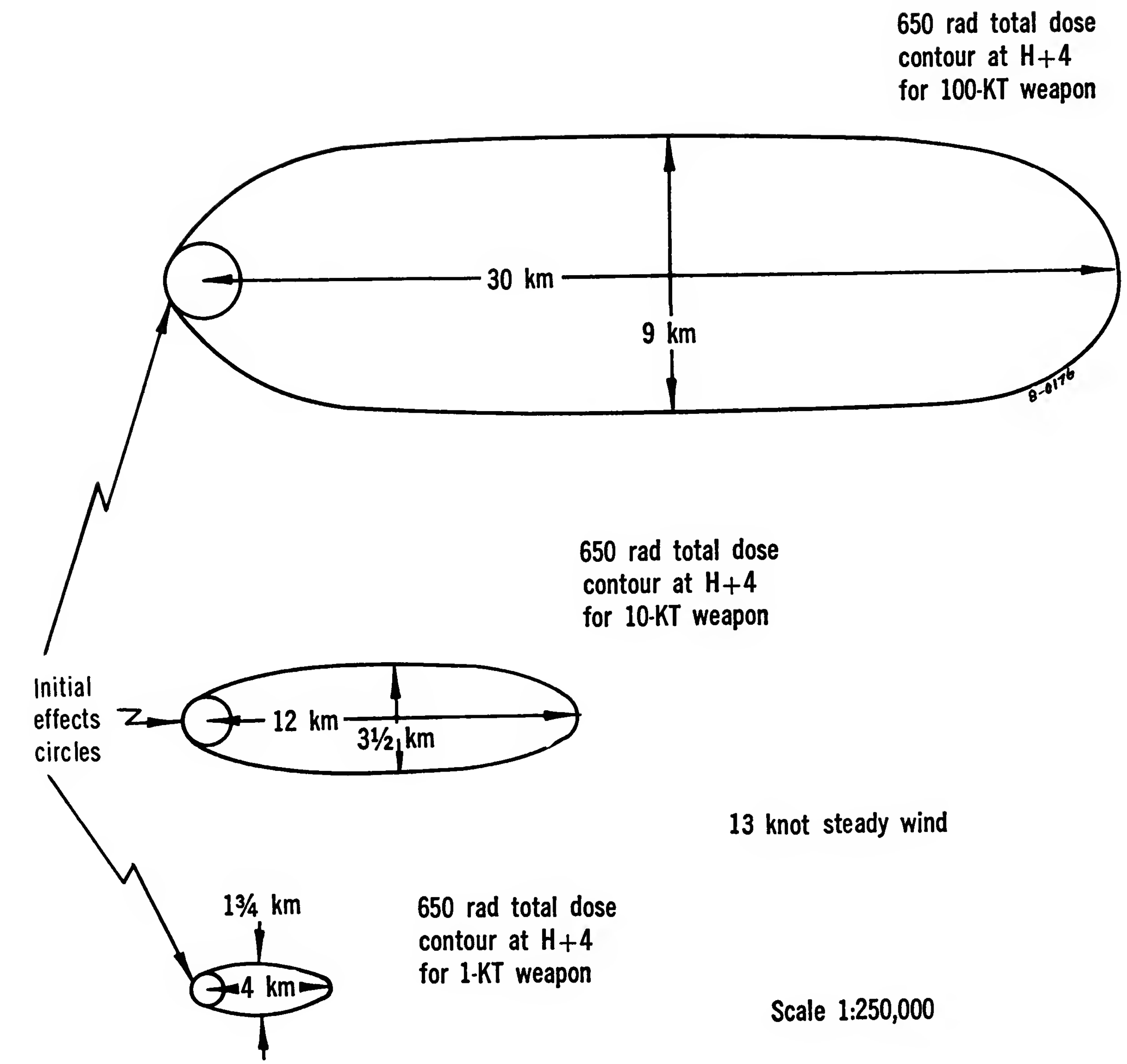


Figure 4–6. Comparison of initial effects and residual effects from 100-, 10-, and 1–kiloton surface bursts.

EFFECT	RISK LEVEL	VULNERABILITY CATEGORY												
		UNWARNED EXPOSED							WARNED EXPOSED					
THERMAL	Negligible	1° burns to bare skin 2.5 percent							1° burns under summer uniform 2.5 percent					
		kilotons	0.01	0.1	1	10	100	1000		W	1	10	100	1000
		cal/cm^2	0.85	1.0	1.15	1.3	1.5	1.75		Q	3.6	4.5	6.3	8.8
	Moderate	1° burns to bare skin 5 percent							1° burns under summer uniform 5 percent					
		kilotons	0.01	0.1	1	10	100	1000		W	1	10	100	1000
		cal/cm^2	.95	1.1	1.3	1.5	1.75	2.0		Q	4	5.2	7.2	10
	Emergency	2° burns to bare skin 5 percent							2° burns under summer uniform 5 percent					
		kilotons	0.01	0.1	1	10	100	1000		W	1	10	100	1000
		cal/cm^2	1.5	1.7	1.9	2.2	2.9	4		Q	4.7	6.1	8.8	12.5

Figure 6–1. Troop safety criteria.

FM 101-31-3

DEPARTMENT OF THE ARMY FIELD MANUAL

STAFF OFFICERS FIELD MANUAL

NUCLEAR WEAPONS EMPLOYMENT

HEADQUARTERS, DEPARTMENT OF THE ARMY

FEBRUARY 1963

ATOMIC DEMOLITION MUNITIONS
on the surface
SEVERE DAMAGE RADII—METERS

Materiel classification	Yield—KT					
	ALFA/ .5	BRAVO/ 1	DELTA/ 5	ECHO/ 10	GOLF/ 50	HOTEL/ 100
Tunnels and mines Heavy masonry or concrete dams and bridges	50	50	125	175	225	300
Tanks and artillery Locomotives Supply depots Engineer earthmoving equip Field fortifications	75	100	175	250	450	600
Engineer truck-mounted equip Earth-covered surface shelters Blast-resistant reinforced concrete bldgs	100	100	200	250	400	525
Military vehicles Railroad cars Communications equip Truss and floating bridges Monumental-type multistory wall-bearing bldgs Heavy steel frame industrial bldgs Multistory, reinforced concrete frame bldgs	150	200	375	500	950	1,250
Oil storage tanks Multistory, reinforced concrete bldgs (small window area) Multistory, steel frame office bldgs Light steel frame industrial bldgs	250	300	475	650	1,125	1,425
Multistory, wall-bearing bldgs (apt house type) Parked combat aircraft	375	450	800	1,000	1,700	2,125
Wood frame bldgs	375	650	1,050	1,325	2,275	2,875

Figure 12.1.

Folded newspapers may not take fire, but loosely crumpled ones will. The answer? Get rid of trash.

A wet mop or broom will snuff out small fires. So will a burlap bag or a small rug soaked in water.

Buckets of water and sand are essential.

Water is an effective fire fighting agent because it smothers and cools at the same time.

Amended Reprint
June, 1940

AIR RAID PRECAUTIONS
HANDBOOK No. 9

(1st edition)

INCENDIARY BOMBS AND FIRE PRECAUTIONS

Issued by the
Ministry of Home Security

LONDON
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

FIG. 1—TYPICAL KILO MAGNESIUM INCENDIARY BOMB.

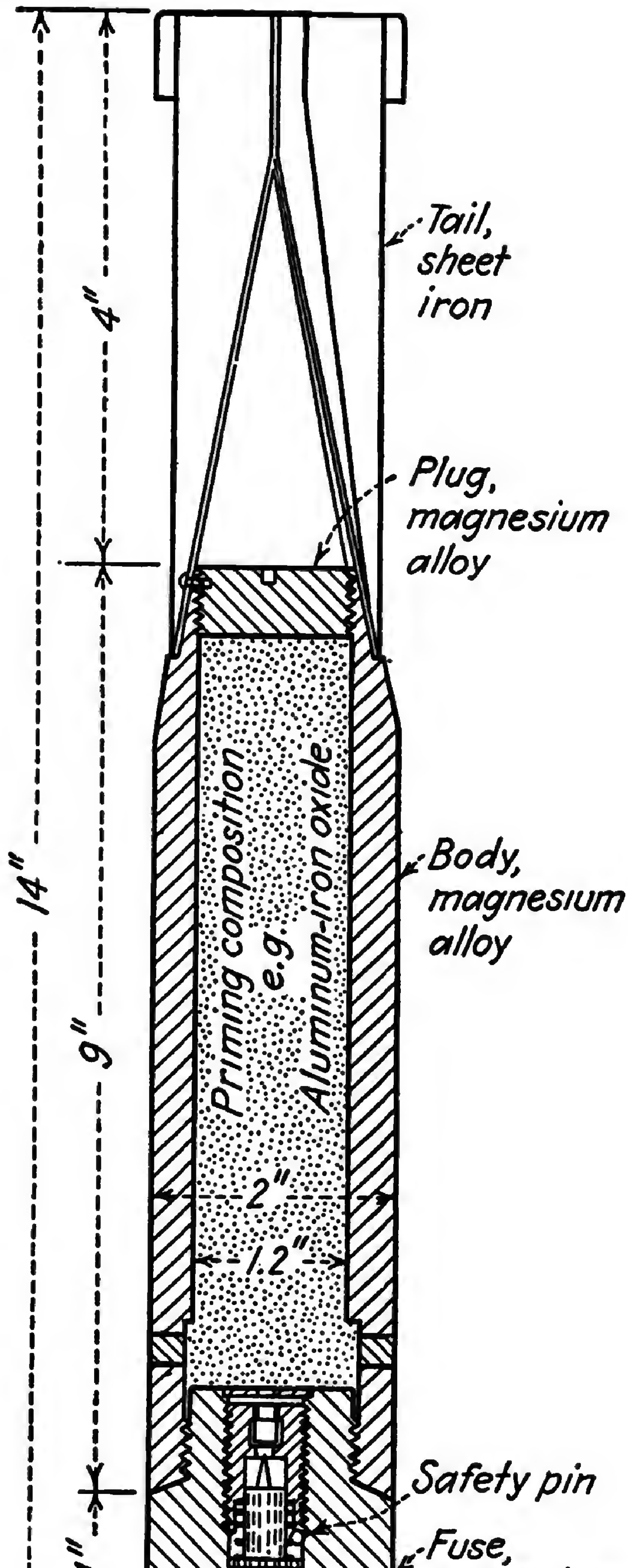
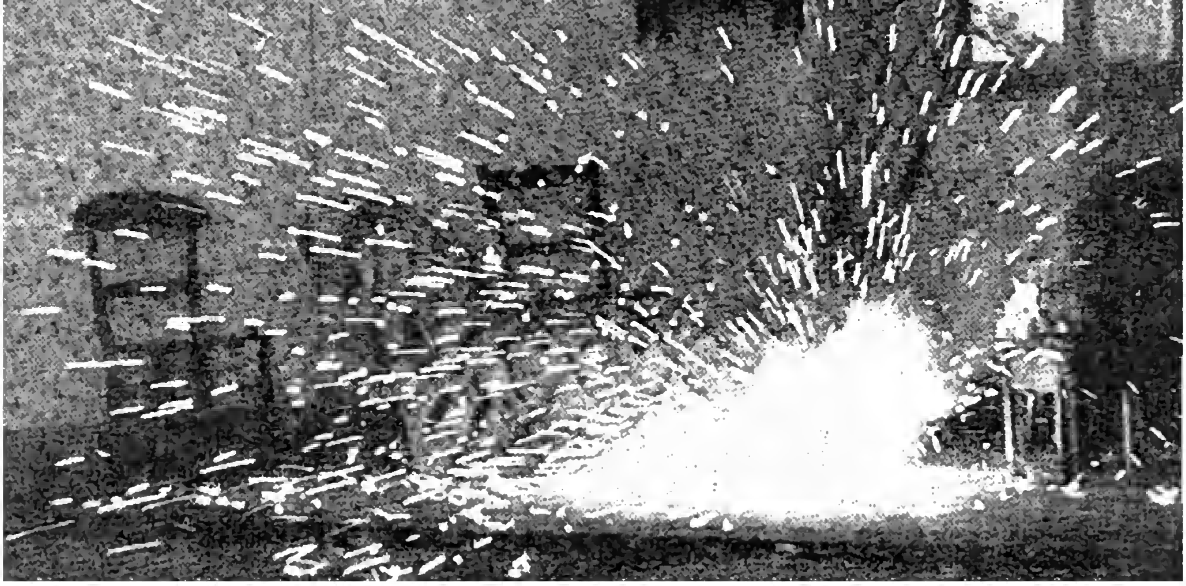
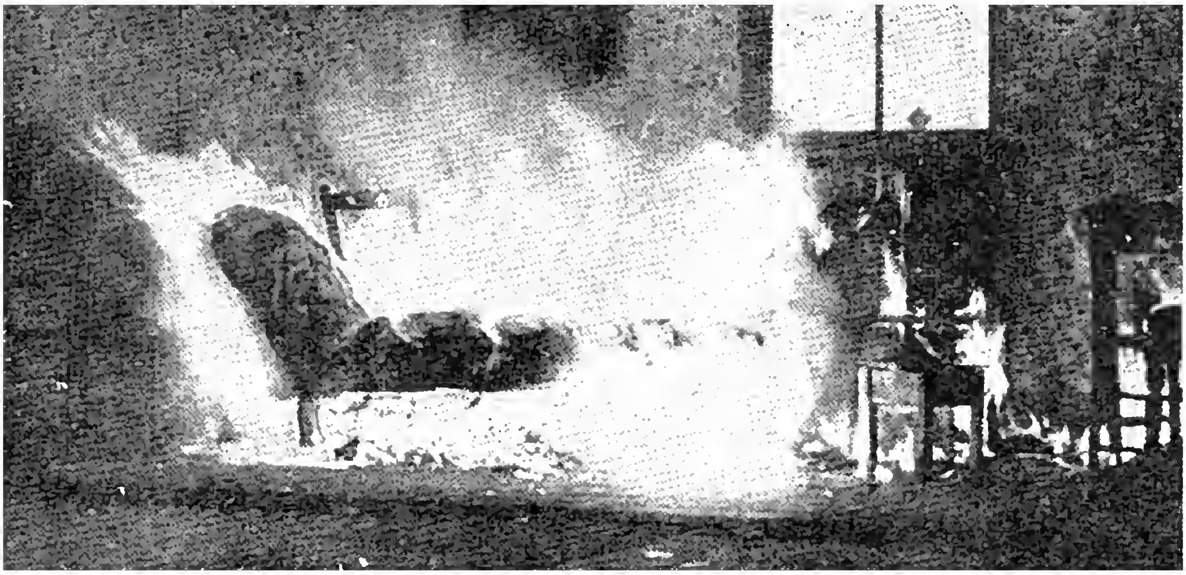


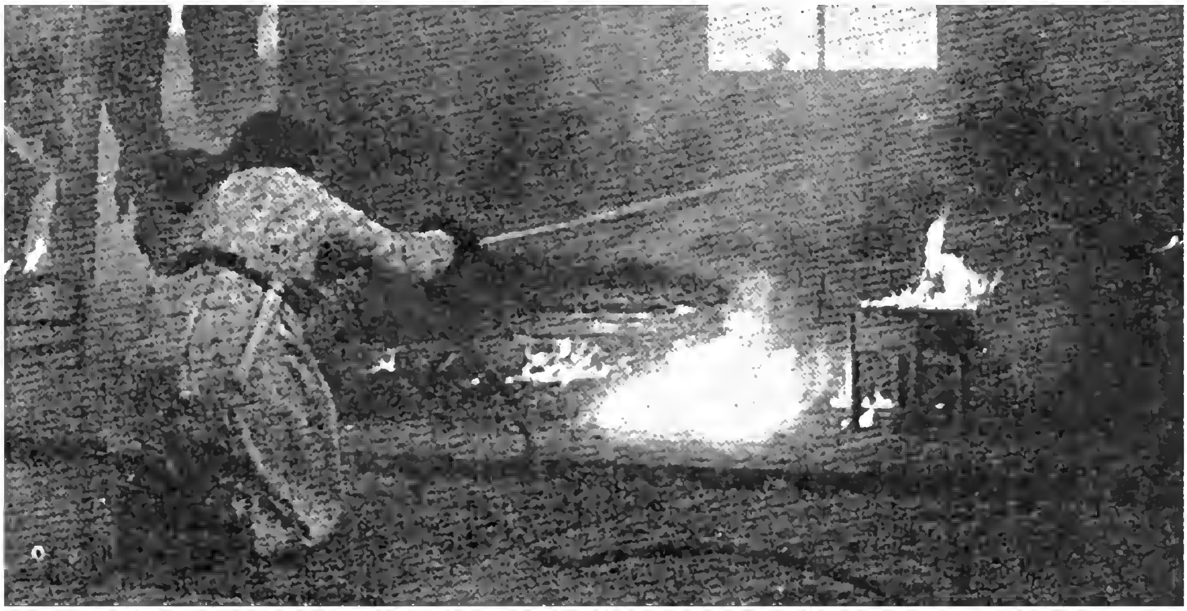
FIG. 2—TYPICAL KILO MAGNESIUM INCENDIARY BOMB. SECTIONAL DRAWING.



KILO MAGNESIUM INCENDIARY BOMB 15 SECONDS AFTER IGNITION.



45 SECONDS



FIRE CONTROLLED BY WATER

Clothing on fire.

Never allow a person whose clothes are on fire to remain standing for a moment. Fatalities nearly always arise from shock of burning about the face and head. If the person starts to run, trip him up at once. Roll him on the floor or in a coat or blanket if you have one handy. If your own clothes catch fire, clap your hand over your mouth, and lie down and roll.

FIRE-BOMBS rained on London

They did not all fall on roads

THE LUFTWAFFE SOUGHT A KNOCK-OUT BLOW. The first impact of the attack fell on the docks. The great day raid of 7th September, 1940, which was continued throughout the night and renewed on many nights after, left miles of fires blazing along either bank of the Thames. This is St. Katherine's Dock on the night of 11th September.

Restricted

For Official Use

CIVIL DEFENCE

TRAINING PAMPHLET NO. 2
(3rd Edition)

OBJECTS DROPPED FROM THE AIR

Issued by the Ministry of Home Security

LONDON
HIS MAJESTY'S STATIONERY OFFICE
1944

Price 6d. net

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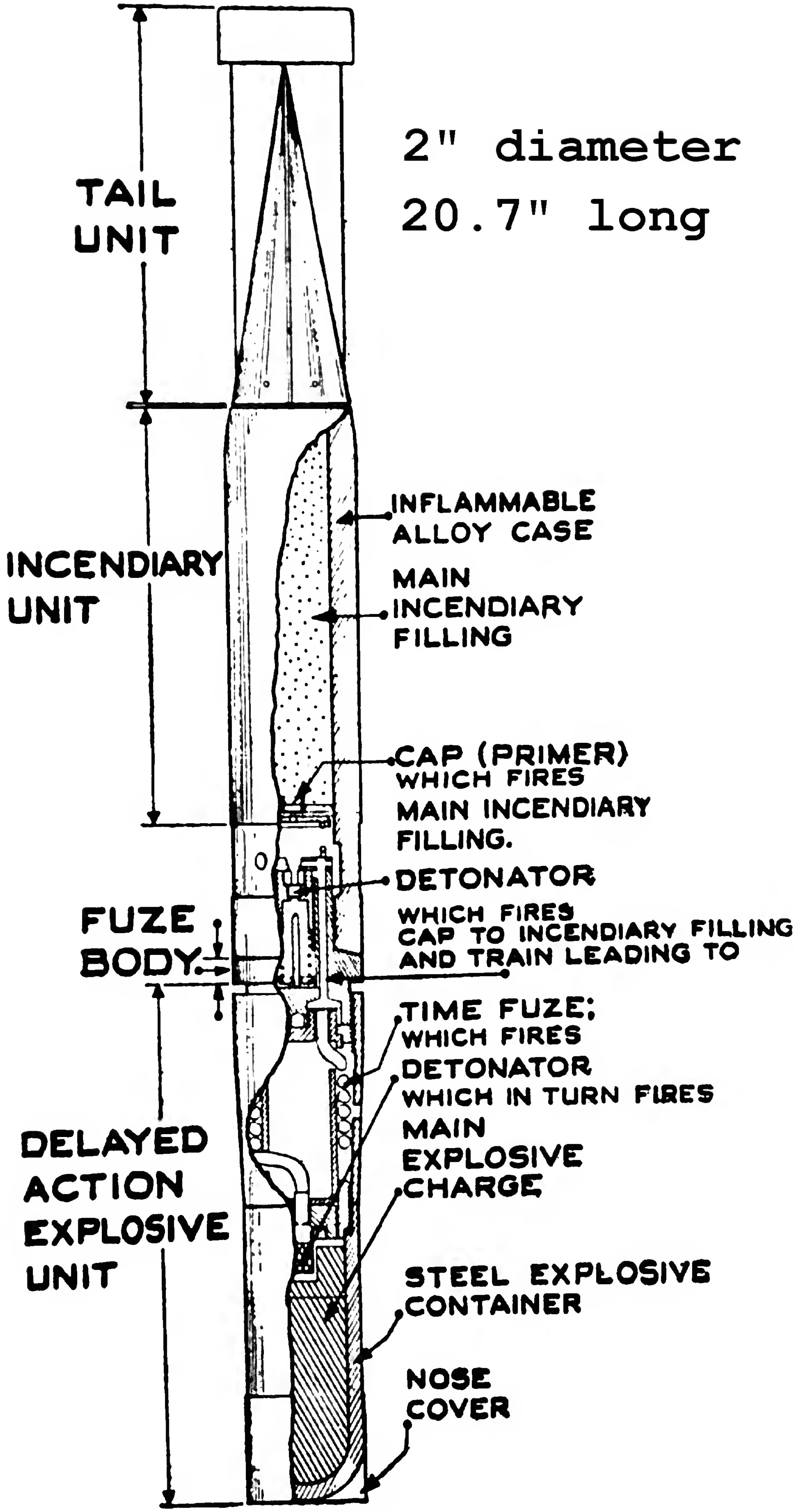

Figure 12a.—German Incendiary Bomb with Explosive Nose

MASS BURNS

Proceedings of a Workshop

13 - 14 March 1968

Accession Number : AD0689495

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1969

Abridged

SOME PRINCIPLES OF PROTECTION AGAINST BURNS FROM FLAME AND INCENDIARY AGENTS

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Flame agents are special blends of petroleum products, usually in thickened form, that ignite easily and can be projected to a target. Methods for the throwing of flame were devised by the Greeks in 429 B.C. (Siege of Plataea) when destructive flammable mixtures of pitch and sulfur were used.

> M1 (Napalm). M1 thickener is a coprecipitated aluminum soap. The name was derived from the naphthenic and palmitic acids that were its major constituents.
>
> Napalm B, used by the Air Force, is intended as a replacement for the M2 thickener. It is not true napalm, being composed of polystyrene, gasoline, and benzene. It is not a gel, but is a sticky, visco-elastic liquid. It has a longer burning time than the M1, M2, and M4 thickened fuels, and, therefore, possibly better incendiary action.
>
> Unlike the M1, M2, and M4 thickeners, which can be quite easily brushed off the skin, the Napalm B is sticky and the polystyrene itself burns, its burning time being longer than that of the petroleum products. Therefore, this does have the required characteristics to produce more severe burns than unthickened fuel.

Troops are instructed to remain covered with no skin exposed until after the flash and flame in the high heat zone have been dissipated and then throw off the cover and remove any burning particles from their clothing. Blankets or items such as an army field jacket have been shown to give real protection. Two thicknesses of the Army shelter half tent will hold burning fuel for more than 10 seconds. Tent canvas and truck tarpaulins which have been treated with fire-resistant material will withstand direct hits with burning fuel and will hold the burning particles for sufficient time (more than 30 seconds) to permit personnel to escape. Foxhole covers improvised of brush with as little as 2 inches of earth on top will successfully withstand burning fuel. The Army plastic poncho is not a satisfactory cover because it melts rapidly and burns when hit with flaming fuel. This would increase the severity of burns received by an individual. Foxholes and weapon positions can be modified to afford adequate protection for anything except a direct hit with a fire bomb.

Metal incendiaries include those consisting of magnesium in various forms, and powdered or granular aluminum mixed with powdered iron oxide. Magnesium is a soft metal which, when raised to its ignition temperature ($623^{o} = 1,150^{o}F$), burns vigorously in air. Magnesium has a burning temperature of about $1,982^{o}C$ ($3,600^{o}F$) depending upon the rate of heat dissipation, rate of burning, and other factors. Its melting point is $651^{o}C$, so it melts as it burns. The liquid metal, burning as it flows, drops to lower levels, igniting combustible materials in its path. Burning stops if oxygen is prevented from reaching the metal or if the metal is cooled below the ignition temperature. Magnesium does not have the highest heat of combustion of the metals, but none of the other metals have been successfully used singly as air-combustible incendiaries. In massive form, magnesium is difficult to ignite. Therefore, a hollow core in the bomb is packed with thermate and an easily ignited mixture which supplies its own oxygen and burns at a very high temperature.[1]

a. Thermite incendiaries.[1] Thermite is essentially a mixture of about 73 per cent powdered ferric oxide (Fe_2O_3) and 27 per cent powdered or granular aluminum. The aluminum has a higher affinity for oxygen than iron has, and if a mixture of iron oxide and aluminum powder is raised to the combustion temperature of aluminum, an intense reaction occurs: $Fe_2O_3 + 2AL \rightarrow AL_2O_3 + Fe$ + heat. Under favorable conditions, the thermite reaction produces temperatures of about $2,200^{o}C$ ($3,922^{o}F$). This is high enough to turn the newly formed metallic iron into a white hot liquid which acts as a heat reservoir to prolong and to spread the heat or igniting action.

Defense against incendiaries, as outlined in a U.S. Army publication is summarized as follows: Incendiary bomb clusters may contain a percentage of high explosive incendiary bombs so precautions should include this possibility. A brick wall offers adequate protection against small explosive incendiary bombs. Incendiary bombs can be scooped up with shovels and thrown into a place where no damage will be done. Sandbags and sandmats can smother bombs and reduce effects of fragmentation. Loose sand helps to smother fires started by the bomb.

Prompt defensive and corrective action makes a very great difference in the severity of injuries resulting from any of these agents.

1. ______, "Military Chemistry and Chemical Agents." Dept. of the Army Tech. Man., TM 3-215, Dept. of the Air Force Manual 355-7, Depts. of The Army and Air Force, 1963.

Abridged

THE BURN SURFACE AS A PARASITE

WATER LOSS, CALORIC DEMANDS, AND THERAPEUTIC IMPLICATIONS

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Water is Lost through Burned Skin

If, during the first 48 hours after injury, no more fluid is given to an extensively burned patient than he would need in health, the uncompensated loss of fluid from his circulation may cause shock, and if sufficiently severe, death.

Heat is Lost Necessitating a High Food Intake

To make matters worse, evaporation of moisture from the wound surface saps not only the body's water stores but its energy stores as well. When water evaporates from the burned surface, cooling results and the body loses heat. The larger the burn wound, the more water loss and the more heat or energy loss.

How Can the Fluid and Heat Losses Be Diminished?

Think Plastic Wrap as Wound Dressing for Thermal Burns

ACEP (American College of Emergency Physicians) News
http://www.acep.org/content.aspx?id=40462

August 2008
By Patrice Wendling
Elsevier Global Medical News

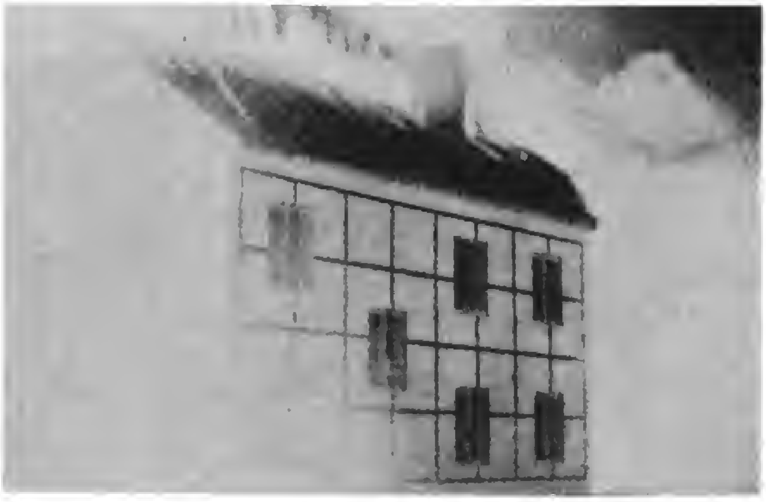
CHICAGO - Ordinary household plastic wrap makes an excellent, biologically safe wound dressing for patients with thermal burns en route to the emergency department or burn unit.

The Burn Treatment Center at the University of Iowa Hospitals and Clinics, Iowa City, has advocated prehospital and first-aid use of ordinary plastic wrap or cling film on burn wounds for almost two decades with very positive results, Edwin Clopton, a paramedic and ED technician, explained during a poster session at the annual meeting of the American Burn Association.

Dr. G. Patrick Kealey, newly appointed ABA president and director of emergency general surgery at the University of Iowa Hospital and Clinics, said in an interview that plastic wrap reduces pain, wound contamination, and fluid losses. Furthermore, it's inexpensive, widely available, nontoxic, and transparent, which allows for wound monitoring without dressing removal.

Hiroshima: overcrowded wood houses

15 min. (Enola Gay)
Hiroshima fires merging



47 kt Greenhouse Easy, Eniwetok Atoll, 1951. Brick house, 3 psi peak overpressure

0.6 second

Impact + 1.0 second

Afterward

[redacted]

THE UNITED STATES
STRATEGIC BOMBING SURVEY

THE EFFECTS OF THE ATOMIC BOMB ON HIROSHIMA, JAPAN

Volume I

Physical Damage Division

May 1947

[redacted]

G. CAUSE AND EXTENT OF FIRE

1. Conditions Prior to Attack

The city of Hiroshima was an excellent target for the atomic bomb from a fire standpoint: There had been no rain for three weeks; the city was highly combustible, consisting principally of Japanese domestic-type structures; it was constructed over flat terrain; and 13 square miles (including streets) of the 26.5-square-mile city was more than 5 percent built up (i. e., covered by plan areas of buildings). The remainder of the city comprised water areas, parks and areas built up below 5 percent. Sixty-eight percent of the 13-square-mile area was 27 to 42 percent built up and the 4-square-mile city center was particularly dense, 93.6 percent of it being 27 to 42 percent built up.

a. Fire Department. Public fire equipment had been little improved in anticipation of wartime fires. Private fire equipment had been augmented somewhat but instruction to home occupants in its use had been limited to training in combating incendiary bombs.

a. Evidence relative to ignition of combustible structures and materials by heat directly radiated by the atomic bomb and by other ignition sources developed the following: (1) The primary fire hazard was present in combustible materials and in fire-resistive buildings with unshielded wall openings; (2) six persons who had been in reinforced-concrete buildings within 3,200 feet of air zero stated that black cotton black-out curtains were ignited by radiant heat; (3) a few persons stated that thin rice paper, cedarbark roofs, thatched roofs, and tops of wooden poles were afire immediately after the explosion; (4) dark clothing was scorched, and, in some cases, reported to have burst into flame from flash heat; (5) but a large proportion of over 1,000 persons questioned was in agreement that a great majority of the original fires was started by debris falling on kitchen charcoal fires, by industrial process fires, or by electric short circuits.

b. Hundreds of fires were reported to have started in the center of the city within ten minutes after the explosion. Of the total number of buildings investigated 107 caught fire, and, in 69 instances, the probable cause of initial ignition of the buildings or their contents was established as follows: (1) 8 by direct radiated heat from the bomb (primary fire), (2) 8 by secondary sources and (3) 53 by fire spread from exposing buildings.

c. *Damage to Rolling Stock*. Of the 123 trolley cars operated by the company, 20 percent were damaged by fire and 45 percent by blast. Of the 85 motor busses, fire damaged 21 percent and blast 26 percent. Radiant heat from the bomb ignited cars and busses within 1,500 feet of GZ. Total damage to cars extended a maximum of 5,700 feet from GZ, heavy damage to 8,400 feet and slight damage to 12,500 feet. Busses were totally damaged at 4,000 feet and heavily damaged 5,500 feet from GZ.

d. *Damage to Overhead System*. Blast and fire damaged 11.4 miles of the overhead transmission system including damage to 500 wood and 100 steel poles. No damage occurred to concrete poles, the nearest of which were 6,000 feet from GZ. Wood poles were damaged at a maximum distance of 4,500 feet from GZ, and steel poles at 3,500 feet. Overhead transmission cable was downed by blast at 8,000 feet.

3. Conditions on Morning of Attack

a. The morning of 6 August 1945 was clear with a small amount of clouds at high altitude. Wind was from the south with a velocity of about 4½ miles per hour. Visibility was 10 to 15 miles.

b. An air-raid "alert" was sounded throughout Hiroshima Prefecture at 0709 hours. Reports of the number of planes causing this alert were conflicting. The governor of the prefecture stated that four B–29s were sighted, while the Kure Naval District reported three large planes.

c. The aircraft apparently came out over Hiroshima from the direction of Bungo Suido and Kunisaki Peninsula, circled the city, and withdrew in the direction of Harima-Nada at 0725 hours. "All-clear" was sounded at 0731 hours.

d. The following circumstances account in part for the high number of casualties resulting from the atomic bomb:

(1) Only a few persons remained in the air-raid shelters after the "all-clear" sounded.

(2) No "alert" was sounded to announce the approach of the planes involved in the atomic-bomb attack.

(3) The explosion occurred during the morning rush hours when people had just arrived at work or were hurrying to their places of business. This concentrated the population in the center of the city where the principal business district was located.

(4) Many persons residing outside the city were present for reasons of business, travel and pleasure.

(5) National volunteer and school units were mobilized and engaged in evacuation operations.

[redacted]

THE UNITED STATES
STRATEGIC BOMBING SURVEY

THE EFFECTS OF THE ATOMIC BOMB ON HIROSHIMA, JAPAN

Volume II

Physical Damage Division

Dates of Survey:

14 October–26 November 1945

Date of Publication

May 1947

[redacted]

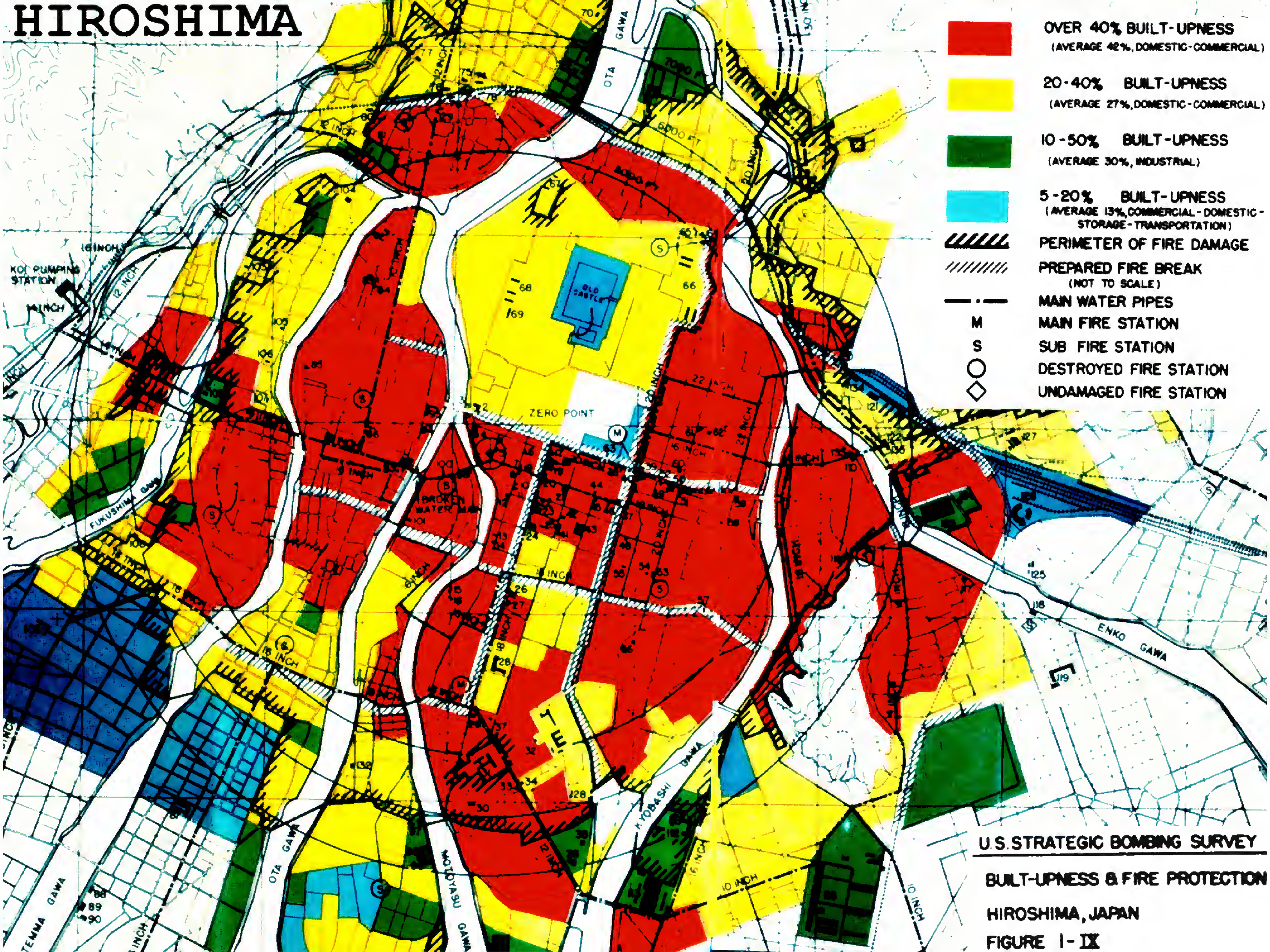
4. The city, consisting principally of Japanese domestic structures, was highly combustible and densely built up. Sixty-eight percent of the 13-square-mile city area was 27 to 42 percent built up and the 4-square-mile city center was particularly dense, 94 percent of it being 27 to 42 percent built up. All the large industrial plants were located on the south and southeast edges of the city.

8. Evidence relative to ignition of combustible structures and materials by directly radiated heat from the atomic bomb and other ignition sources was obtained by interrogation and visual inspection of the entire city. Six persons who had been in reinforced-concrete buildings within 3,200 feet of air zero stated that black cotton black-out curtains were ignited by flash heat. A few persons stated that thin rice paper, cedarbark roofs, thatched roofs, and tops of wooden poles were afire immediately after the explosion. Dark clothing was scorched and, in some cases, was reported to have burst into flame from flash heat. A large proportion of over 1,000 persons questioned was, however, in agreement that a great majority of the original fires were started by debris falling on kitchen charcoal fires. Other sources of secondary fire were industrial-process fires and electric short circuits.

9. There had been practically no rain in the city for about 3 weeks. The velocity of the wind on the morning of the atomic-bomb attack was not more than 5 miles per hour.

10. Hundreds of fires were reported to have started in the center of the city within 10 minutes after the explosion.

HIROSHIMA



U.S. STRATEGIC BOMBING SURVEY

BUILT-UPNESS & FIRE PROTECTION

HIROSHIMA, JAPAN

FIGURE I-IX

D. THE CONFLAGRATION

1. Start of Fire

b. Direct Ignition by the Atomic Bomb. (1) Six persons were found who had been in reinforced-concrete buildings within 3,200 feet of AZ at the time of the explosion and who stated that black cotton black-out curtains were blazing a few seconds later. In two cases it was stated that thin rice paper on desks close to open windows facing AZ also burst into flame immediately, although heavier paper did not ignite. No incidents were recounted to the effect that furniture or similar objects within buildings were ignited directly by radiated heat from the bomb.

21

(8) Scores of persons throughout all sections of the city were questioned concerning the ignition of clothing by the flash from the bomb. Replies were consistent that white silk seldom was affected, although black, and some other colored silk, charred and disintegrated. Numerous instances were reported in which designs in black or other dark colors on a white silk kimono were charred so that they fell out, but the white part was not affected. These statements were confirmed by United States medical officers who had been able to examine a number of kimonos available in a hospital. Ten school boys were located during the study who had been in school yards about 6,200 feet east and 7,000 feet west, respectively, from AZ. These boys had flash burns on the portions of their faces which had been directly exposed to rays of the bomb. The boys' stories were consistent to the effect that their clothing, apparently of cotton materials, "smoked," but did not burst into flame. Photo 36 shows a boy's coat that started to smolder from heat rays at 3,800 feet from AZ.

24

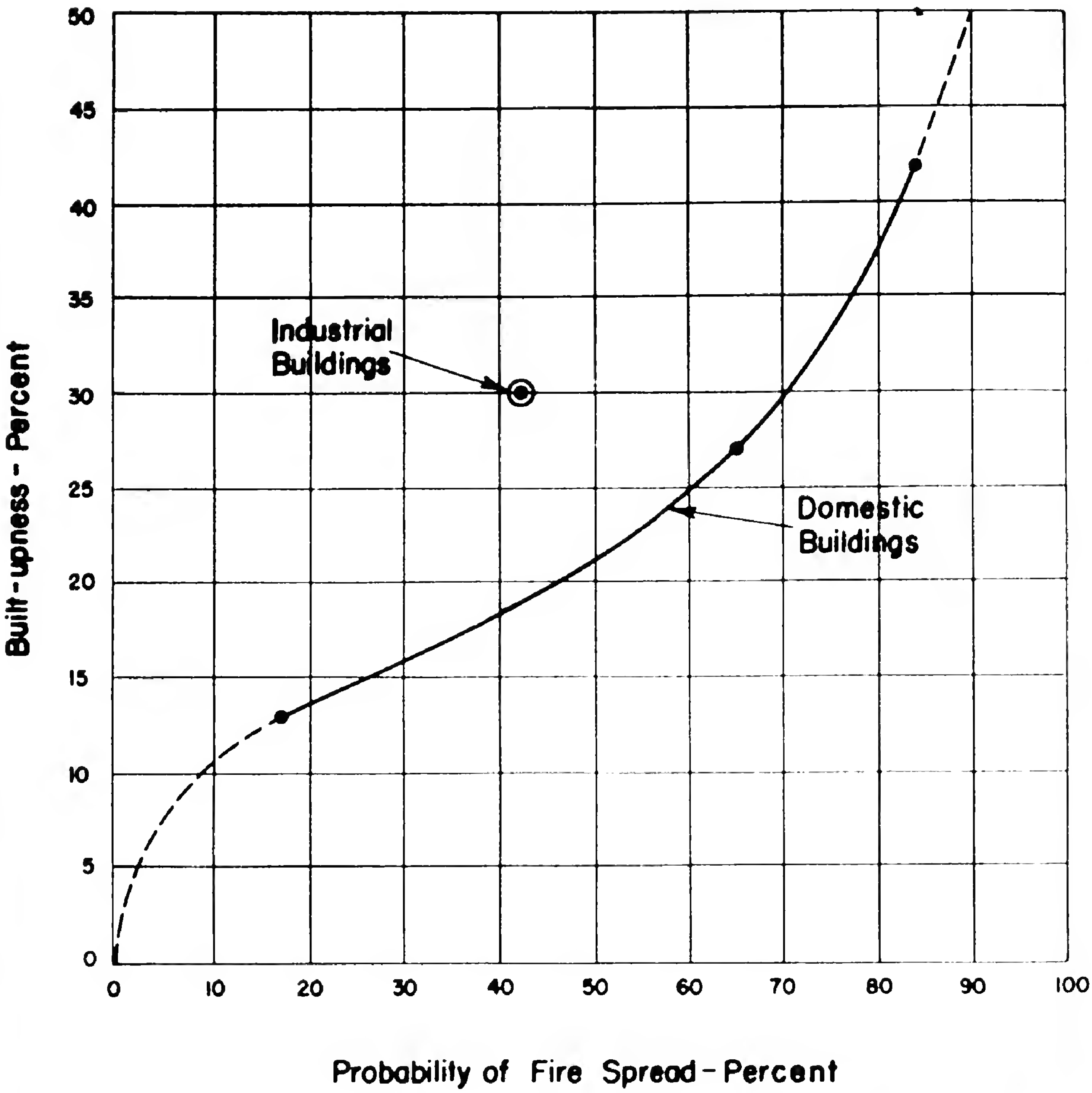
PHOTO 36: jacket outdoors near City Hall (building 28), 3800 ft from AZ

PHOTO 36 IX. Shows partly burned coat of boy who was in open near City Hall (Building 28) 3,800 feet from AZ.

3800 feet from air zero;
3300 feet from ground zero

27

PROBABILITY OF FIRE SPREAD IN VARIOUS AMOUNTS OF BUILT-UPNESS



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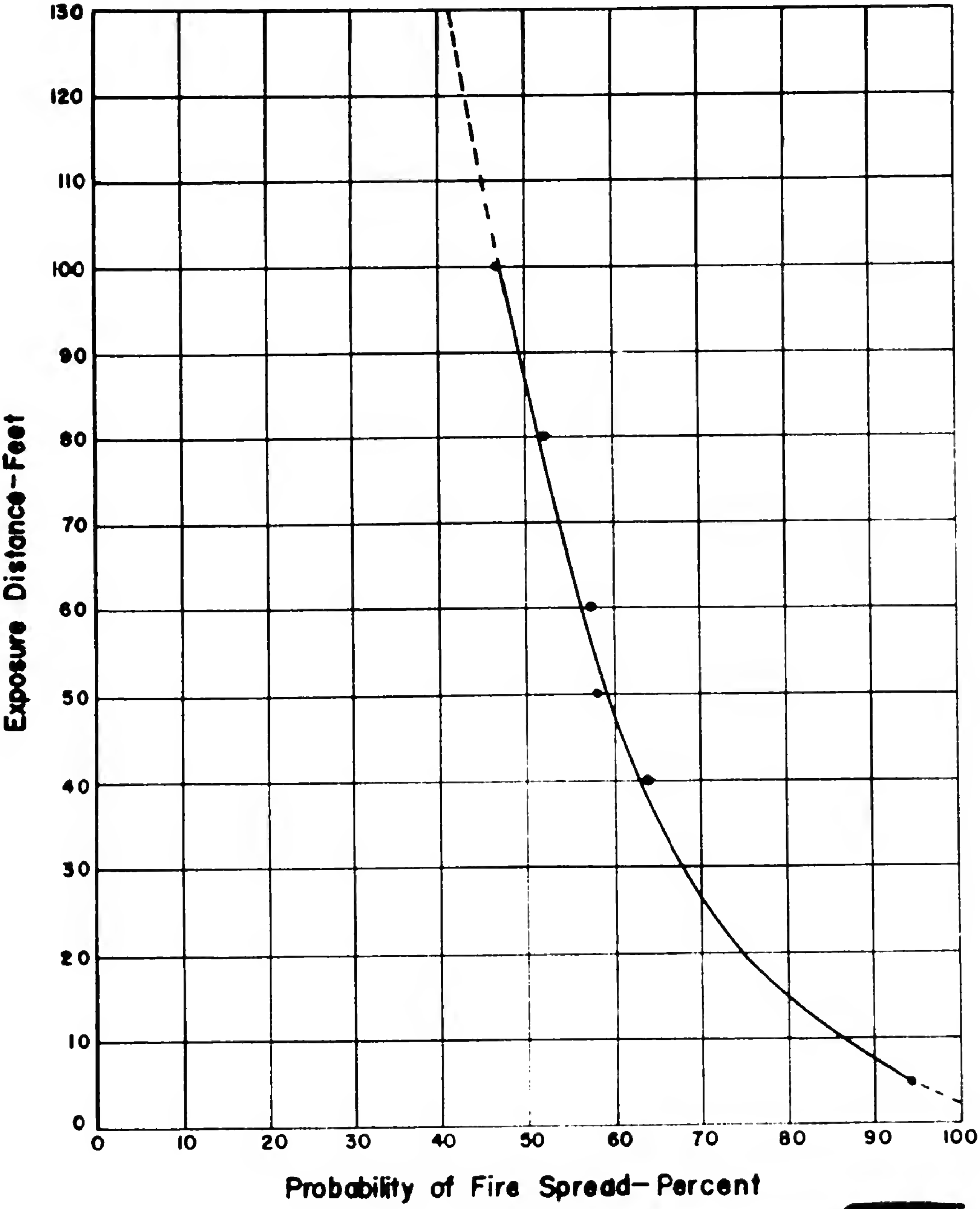
U.S. STRATEGIC BOMBING SURVEY
FIRE SPREAD VS. BUILT-UPNESS
HIROSHIMA, JAPAN
FIGURE 4-IX

[redacted]

PROBABILITY OF FIRE SPREAD ACROSS VARIOUS EXPOSURE DISTANCES



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U. S. STRATEGIC BOMBING SURVEY

FIRE SPREAD VS. EXPOSURE DISTANCES
HIROSHIMA, JAPAN
FIGURE 5 - IX

TABLE 5.—*Fire-resistive building data (fire)*

Building No.	Coordinates	Distance from AZ (feet)	Distance from GZ (feet)	Occupancy	Fire shutters on wall openings	Unprotected wall openings exposed to AZ at zero hour	Distance from unprotected wall openings to nearest burned building (feet)	Probable cause of initial ignition	Number of stories	Stories burned (after blast damage)	Areas in thousands square feet: Total floor area	Areas in thousands square feet: Floor area burned	Percent floor area burned
1	4H	2,100	700	Office	No	Yes	0		B-2	1-2	4.2	3.5	83
2	4H	2,100	800	do	No	Yes	20		B-3	60% B, 100% 1-3	27.3	24.3	89
6	5H	2,100	600	do	Yes	Probably no	10	Fire spread	B-3	70% B, 100% 1-3	16.6	15.3	92
7	5H	2,100	600	Bank	Yes	Yes	6	do	2	1-2	5.7	5.7	100
8	5H	2,100	600	do	Yes	Yes	10	do	3	1-3	9.0	9.0	100
9	5H	2,100	600	Office	Yes	Yes	10	do	B-3	1-3	4.9	4.2	86
10	5H	2,100	600	do	Yes	Yes	10	do	2	1-2	2.5	2.5	100
11	5H	2,100	700	do	No	Yes	30		3	1-3	9.8	9.8	100
12	5H	2,100	700	do	No	Yes	10		B-3	B-3	15.8	15.8	100
18	5H	2,200	1,000	Bank	Part	Probably no	10	Fire spread	B-5	B-5	46.4	46.4	100
19	5H	2,200	1,000	do	Yes	Yes	20	Primary	B-4	75% 1-2, 100% 3-4	29.9	25.2	84
20	5H	2,200	1,000	Office	Part	Yes	10		3	1-3	4.5	4.5	100
21	5H	2,300	1,300	Bank	Yes	Yes	15	Primary	2	1-2	7.3	7.3	100
22	5H	2,300	1,100	Office	Part	Yes	10		4	1-4	20.4	20.4	100
23	5H	2,300	1,200	do	No	Yes	10		B-7	1-7	43.3	39.0	90
24	5H	2,400	1,300	Bank	Yes	Yes	25	Fire spread	B-3	5% 2, 100% 3	32.8	5.2	16
25	5H	2,400	1,400	Art museum	Part	Yes	10		2	1-2	5.4	5.4	100
26	5H	3,000	2,300	Office	Part	Yes	10	Primary	B-5	40% B, 100% 1-5	52.0	46.5	88
27	6H	3,100	2,400	Library	Part	Yes	25		4	1-4	13.4	13.4	100
28	6H	3,800	3,300	Office	No	Yes	50	Fire spread	B-4	80% B-1, 100% 2-4	93.4	84.9	91
31	6H	5,300	4,900	Hospital	No	Yes	75	No fire	B-3	None	88.6	0	0
32A	6H	5,100	4,700	Classrooms	No	Yes	25	Fire spread	2	1-2	2.8	2.8	100
32B	6H	5,200	4,800	Library	Yes	No	5	do	2	1-2	3.7	3.7	100
32D	6H	5,000	4,600	Classrooms-laboratories	No	Yes	30	Secondary	3	1-3	103.3	103.3	100
32E	6H	4,700	4,200	Classrooms	No	Yes	30	Fire spread	3	1-3	39.5	39.5	100
32F	6H	5,000	4,600	Laboratory	No	Yes	12	do	1	1	2.0	2.0	100
32G	6H	5,200	4,800	Kitchen	No	Yes	0	do	1	None	3.0	3.0	0
32H	6H	5,300	4,900	Laboratory	No	Yes	6	do	2	1-2	3.8	3.8	100
33	6H	5,600	5,300	Office	Part	Yes	90	do	B-4	None	62.6	0	0
38	5H	2,900	2,100	do	No	Yes	20	do	B-3	B-3	10.4	10.4	100
39	5I	3,200	2,500	do	Part	Yes	10	Primary	4	1-4	32.0	32.0	100
40	5H	3,200	2,500	Department store	No	Yes	50	do	B-7	B-7	78.9	78.9	100
41	5H	2,600	1,700	Classrooms	No	Yes	20		B-3	75% B, 100% 1-3	26.4	25.1	95
43	5H	2,800	2,000	Telephone exchange	Part	Yes	35	Secondary	3	1-3	36.1	36.1	100
44	5H	2,700	1,800	Department store	Yes	Yes	5		3	1-3	4.3	4.3	100
45	5H	2,700	1,800	Bank	Yes	Yes	0		3	1-3	8.0	8.0	100
47	5H	3,100	2,300	Beer hall	No	Yes	20	Fire spread	B-3	1-3	15.3	13.2	86
48	5H	3,300	2,600	Hospital	No	Yes	6		2	1-2	2.9	2.9	100
49	5I	3,600	3,000	Office	Part	Yes	90	Primary	7	1-7	14.7	14.7	100
50	5I	3,600	3,000	Newspaper plant	No	Yes		Fire spread	3	1-3	24.5	24.5	100
51	5I	3,700	3,200	Bank	Part	Yes	40	Primary	B-3	15% B, 100% 1-3	26.7	19.2	72
59	5I	4,500	4,100	Office	Part	Yes	30	Fire spread	B-3	None	16.2	0	
61	5I	4,000	3,400	Radio station	No	Yes	15		2	1-2	8.3	8.3	100
62	5I	4,100	3,600	Residence	No	Yes	0		2	1-2	2.2	2.2	100
64	3I	5,300	4,900	Hospital	No	Yes	30	Primary	B-2	Second only	15.9	5.3	33
65	3I	5,300	4,900	Office	No	Yes	30	Fire spread	4	50% 1-3, 90% 4	83.4	50.0	60
67	3H	5,000	4,600	Munitions storage	Yes	No	125	No fire	1	None	1.7	0	0
74	3H	6,300	6,000	Electrical laboratory	No	Yes	30	Fire spread	B-2	70% B-1, 100% 2	13.2	10.6	80
76	3G	6,200	5,900	Warehouse	Yes	Yes	0	do	1	1	15.9	15.9	100
79	3G	6,100	5,800	do	Yes	Yes	6	do	2	1-2	14.4	14.4	100
85	4G	3,800	3,300	Telephone exchange	Yes	Probably no	125	Secondary	3	25% second only	14.2	1.1	8
86	5G	2,800	2,000	Classrooms	No	Probably no	125	No fire	3	None	11.5	0	0
93	5G	2,500	1,500	Warehouse	Yes	No	0	Fire spread	2	1-2	2.9	2.9	100
95	4G	2,300	1,200	Classrooms	No	Yes	30		B-3	B-3	49.5	49.5	100
96	5G	2,000	400	Clothing store	No	Yes	10		B-3	1-3	12.4	9.3	75
100	5G	2,100	800	Office	No	Yes	0		2	1-2	3.0	3.0	100
101	5G	2,600	1,700	Warehouse	Yes	Probably no	5	Fire spread	2	1-2	4.3	4.3	100
113C	7I	7,700	7,400	Cigarette manufacture	No	Yes	60	No fire	1	None	54.6	0	0
122	5J	6,700	6,400	Bank	Yes	Probably no	5	Fire spread	2	None	5.1	0	0
129	3G	6,000	5,600	do	No	Yes	12	No fire	B-2	None	16.2	0	0
132	6G	5,700	5,400	Warehouse	Yes	No	0	Fire spread	B-1	B-1	15.0	15.0	100
133	5J	6,200	5,900	Mercantile	No	Yes	0	do	4	1-4	3.0	3.0	100
134	4J	6,300	6,000	Office	Yes	Yes	60	do	3	80% 1, 100% 2-3	4.8	4.5	94
135	5J	6,800	6,500	Bank	Yes	Yes	100	No fire	B-2	None	9.0	0	0

SOURCE: USSBS's Secret report, "The Effects of the Atomic Bomb on Hiroshima, Japan," vol. 2 Only 8 of 64 non-wood buildings had thermal flash ignition evidence, 3 had blast damage induced fire, and 28 were ignited by firespread from wood homes.

(4) It was reported that a cotton black-out curtain at an unprotected window in the east stair tower of Building 85 (3,800 feet from AZ) smoked and was scorched by radiated heat from the bomb but it did not burst into flames. All windows other than those in the stair tower were protected by closed steel-roller shutters. There was fire damage in a few telephone relay units in the second story but this was caused by electrical short circuits when debris from windows was blown into the equipment by blast.

(5) A man who was in the third story of building 26 (3,000 feet from AZ) stated that radiated heat from the bomb ignited cotton black-out curtains at unprotected windows in the west wall and thin rice paper on desks. According to his recollection, all stories were afire five minutes after the attack. On the other hand, two men who were working in Building 28 (3,800 feet from AZ) stated that there was no primary fire in this building, the windows of which were not equipped with fire shutters. Black-out curtains at all windows were drawn back and no fires started in them. According to the same men, fire spread into the building by flying brands from the south nearly two hours after the attack.

(10) Fire fighting with water buckets was reported inside only four buildings (24, 33, 59, and 122) and probably prevented extensive fire damage in them. In Building 24, fire was started in contents of a room at the southwest corner of the second story by sparks from trees on the south side about 1½ hours after the attack. Men inside the building extinguished the fire and probably prevented further damage in the first and second stories (Photo 85). A little later, contents in the third story were ignited by sparks from the outside and were totally damaged. This fire was beyond control before it was discovered, but did not spread downward through open stairs. At Building 33, sparks from the west exposure, which burned in early evening, set fire to black-out curtains in the west wall and to waste paper in the fourth story of the northwest section of the building. Twenty persons were on guard in the building awaiting such an occurrence and the fires were quickly extinguished while in the incipient stage. At Building 59 sparks from the south exposure ignited a few pieces of furniture in the first and third stories and black-out curtains in the first story about 2 hours after the attack. These fires were extinguished by men inside and negligible damage resulted. A few window frames in the east and west walls and 2 or 3 desks in the first story of Building 122 were ignited by radiated heat and sparks from the west and northeast exposures. These fires were extinguished quickly and damage was negligible.

A. SUMMARY

4. The mean areas of effectiveness (MAE) of the atomic bomb for structural damage about ground zero (GZ) and the radii of the MAE's for the several classes of buildings present were computed to be as follows:

	MAE's in square miles	Radii of MAE's in feet
Multistory, earthquake-resistant	0. 03	500
Multistory, steel- and reinforced-concrete frame (including both earthquake- and non-earthquake-resistant construction)	. 05	700
1-story, light, steel-frame	3. 4	5, 500
Multistory, load-bearing, brick-wall	3. 6	5, 700
1-story, load-bearing, brick-wall	6. 0	7, 300
Wood-frame industrial-commercial (dimension-timber construction)	8. 5	8, 700
Wood-frame domestic buildings (wood-pole construction)	9. 5	9, 200
Residential construction	6. 0	7, 300

STRUCTURAL DAMAGE BY BLAST
TO
MULTI-STORY, STEEL- AND REINFORCED-CONCRETE-FRAME BUILDINGS
(BASED ON TOTAL FLOOR AREA)

MAE FOR ALL STEEL-& REINF.-CONC.-FRAME BLDGS = 0.05 SQ MI
MAE FOR EARTHQUAKE-RESISTANT BLDGS ONLY = 0.03 SQ MI

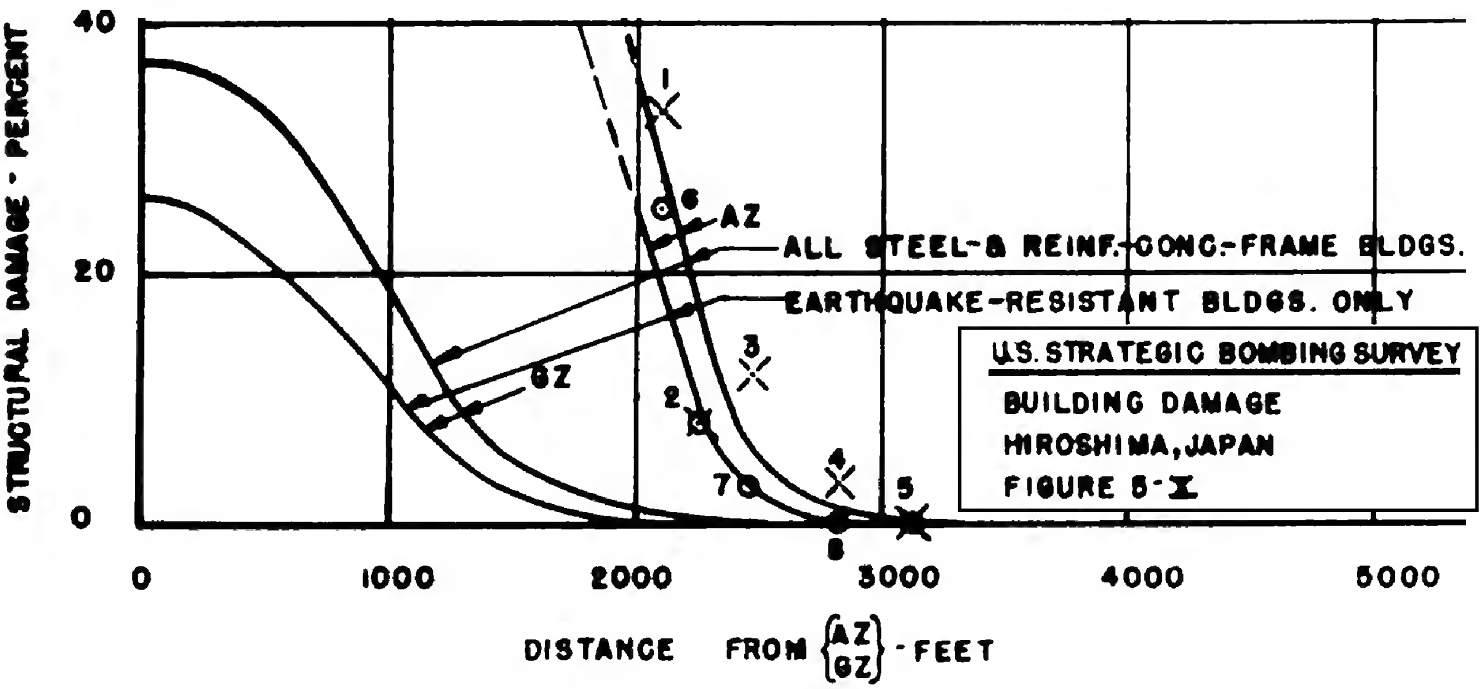

Table 1.—*Building data, steel- and reinforced-concrete-frame*

[Areas in thousands of square feet]

Building	Grid	Occupancy	Type	Plan area	Stories	Building HE-V	Building fire-V	Distance AZ-(feet)	Total floor area	Building damage—floor area: Structural damage: Blast	Structural damage: Fire	Structural damage: Mixed	Superficial damage: Blast	Superficial damage: Fire	Internal fire	Content damage: Percent	Content damage: Cause
1	4H	Office	E1	1.7	2	V-1	R	2,100	4.2	1.8					3.5	90	Fire.
2	4H	do	E1	8.3	2/3	V-1	R	2,200	27.3	1.1					24.3	90	Do.
6	5H	do	E1	5.1	3	V-1	R	2,100	16.6						15.3	95	Do.
8	5H	Bank	E1	5.3	1/3	V-1	R	2,100	9.0	5.3					9.0	100	Do.
9	5H	Office	E1	2.1	2/3	V-1	R	2,100	4.9	1.0					4.2	90	Do.
11	5H	do	E1	4.6	3	V-1	R	2,100	9.8	2.1					9.8	100	Do.
18	5H	Bank	E1	10.1	5/2	V-1	R	2,200	45.0	1.9					46.4	100	Do.
19	5H	do	E1	8.8	4	V-1	R	2,200	29.9	2.7					25.2	90	Do.
20	5H	Office	E1	1.5	3	V-1	R	2,200	4.5	.1					4.5	100	Do.
21	5H	Bank	E1	5.5	1/2	V-1	R	2,300	7.3	5.7					7.3	100	Mixed.
22	5H	Office	E1	4.7	4	V-1	R	2,300	20.4	1.6			2.1		20.4	100	Fire.
23	5H	do	E1	5.4	7	V-1	R	2,300	43.3	4.6					39.0	90	Do.
24	5H	Bank	E1	10.6	3	V-1	R	2,400	32.8						5.2	30	Mixed.
26	5H	Office	E1	9.2	5	V-1	R	3,000	52.0				.2		46.5	90	Fire.
27	5H	Library	E1	5.3	2/4	V-1	R	3,100	13.4		0.8				13.4	100	Do.
28	6H	Office	E1	21.3	4	V-1	R	3,800	93.4						84.9	95	Do.
31	6H	Hospital	E1	27.5	3/4	V-1	R	5,300	88.6						0	25	Debris.
32A	6H	Classrooms	E1	1.4	2	V-1	R	5,100	2.8						2.8	100	Fire.
32B	6H	Library	E1	1.9	2	V-1	R	5,200	3.7						3.7	100	Do.
32D	6H	Classroom laboratory	E1	34.4	3	V-1	R	5,000	103.3						103.3	100	Do.
32E	6H	Classrooms	E1	13.2	3	V-1	R	4,700	39.5						39.5	100	Do.
33	6H	Office	E1	11.2	4	V-1	R	5,600	62.6						0	15	Blast-debris.
38	5H	do	E1	2.6	3	V-1	R	2,900	10.4						10.4	100	Fire.
39	5I	do	E1	15.5	3/4	V-1	N/R	3,200	32.0				4.4		32.0	100	Do.
40	5H	Department store	E1	9.9	7	V-1	R	3,200	78.9						78.9	100	Do.
41	5H	Classrooms	E1	7.2	3	V-1	R	2,600	26.4						25.1	95	Do.
43	5H	Telephone exchange	E1	16.3	2/3	V-1	R	2,800	36.1						36.1	100	Do.
44	5H	Department store	E1	2.6	1/3	V-1	R	2,700	4.3	1.7					4.3	100	Do.
47	5H	Beer hall	E1	4.8	3	V-1	R	3,100	15.3						13.2	80	Do.
49	5I	Office	E1	2.1	7	V-1	R	3,600	14.7						14.7	100	Do.
50	5I	Newspaper	E1	10.3	2/3	V-1	R	3,600	24.5						24.5	100	Do.
51	5I	Bank	E1	9.0	1/3	V-1	R	3,700	26.7						19.2	80	Do.
59	5I	Office	E1	4.8	2/3	V-1	R	4,500	16.2						0	10	Blast.
61	5I	Radio station	E1	4.2	2	V-1	R	4,000	8.3						8.3	100	Fire.
62	5I	Residence	E1	1.1	2	V-1	R	4,100	2.2						2.2	100	Do.
64	3I	Hospital	E1	6.8	2	V-1	R	5,300	15.9						5.3	40	Mixed.
65	3I	Office	E1	20.8	4	V-1	R	5,300	83.4						50.0	70	Do.
74	3H	Electrical laboratory	E1	6.6	2	V-1	R	6,300	13.2						10.6	80	Fire.
79	3G	Warehouse	E1	7.7	2	V-1	R	6,100	14.4		9.9			2.3	14.4	100	Do.
85	4G	Telephone exchange	E1	4.8	3	V-1	R	3,800	14.2						1.1	50	Mixed.
86	5G	Classrooms	E1	3.8	3	V-1	R	2,800	11.0						0	30	Debris.
95	4G	do	E1	12.4	3	V-1	R	2,300	49.5	0.5			3.0		49.5	100	Fire.
98	5G	Clothing store	E1	4.1	3	V-1	R	2,000	12.4	3.9					9.3	75	Do.
116A	7J	Warehouse	E1	23.7	3	V-1	R	8,800	71.1						0	0	
116B	7J	do	E1	23.7	3	V-1	R	8,900	71.1						0	0	
116C	7J	do	E1	23.7	3	V-1	R	9,000	71.1						0	0	
116F	7J	do	E1	23.7	3	V-1	R	9,200	71.1						0	0	
122	5J	Bank	E1	2.6	2	V-1	R	6,700	5.1						0	0	
12	5H	Office	E2	4.5	3	V-3	R	2,100	15.8	10.8			0.7		15.8	100	Mixed.
16	5H	Electric substation	E2	1.6	3	V-3	N	3,100	4.1				4.1		2.5	50	Do.
25	5H	Art museum	E2	3.3	2	V-3	R	2,400	5.4	0.3			2.1		5.4	100	Fire.
46	5H	Jewelry store	E2	.9	2	V-3	N/C	2,800	1.9	1.9					1.9	100	Mixed.
48	5H	Hospital	E2	1.5	2	V-3	R	3,300	2.9						2.9	100	Fire.
93	5G	Warehouse	E2	1.5	2	V-3	R	2,500	2.9	2.9					2.9	100	Mixed.
100	5G	Office	E2	1.5	2	V-3	R	2,100	3.0				.1		3.0	100	Fire.
101	5G	Warehouse	E2	2.2	2	V-3	R	2,600	4.3	4.3					4.3	100	Debris.
121	4J	Railroad station	E1	9.0	1/2	V-3	N/C	6,600	14.0	4.9	4.9				14.0	100	Fire.
67	3H	Munitions storage	A2.4	1.7	1	V-4	R	5,000	1.7	1.7					0	10	Exposure.
76	3G	Warehouse	A2.4	15.9	1	V-4	R	6,200	15.9	1.9					15.9	100	Fire.
113C	7I	Cigarette manufacturing	A1.2	54.6	1	V-4	R	7,700	54.6						0	0	
113D	7I	do	A1.2	54.9	1	V-4	R	7,800	54.9						0	0	
126A	5K	Railroad roundhouse	A2.4	21.1	1	V-4	R	8,900	21.1						0	0	
126B	5K	do	A1.2	11.6	1	V-4	R	9,000	11.6						0	0	


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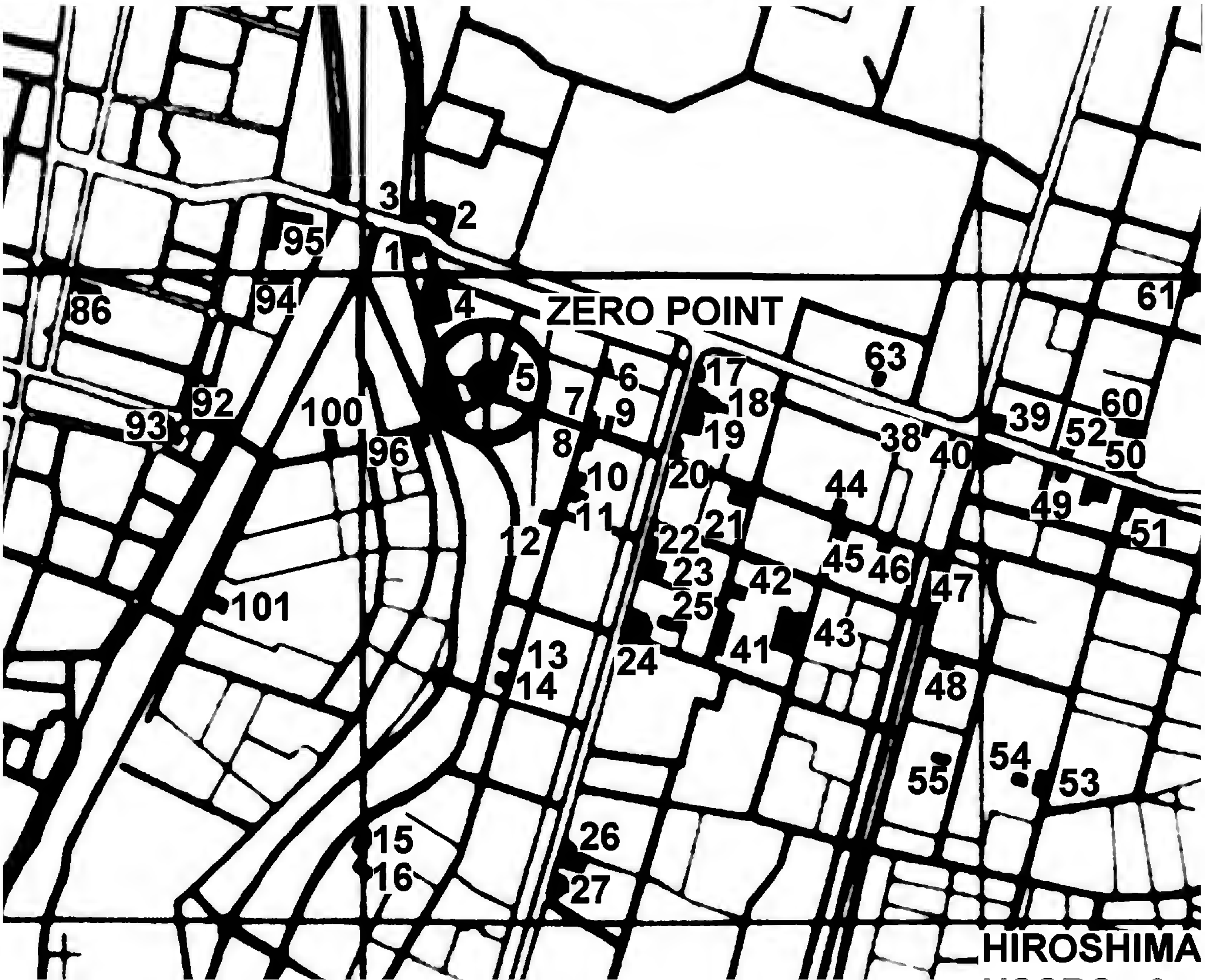
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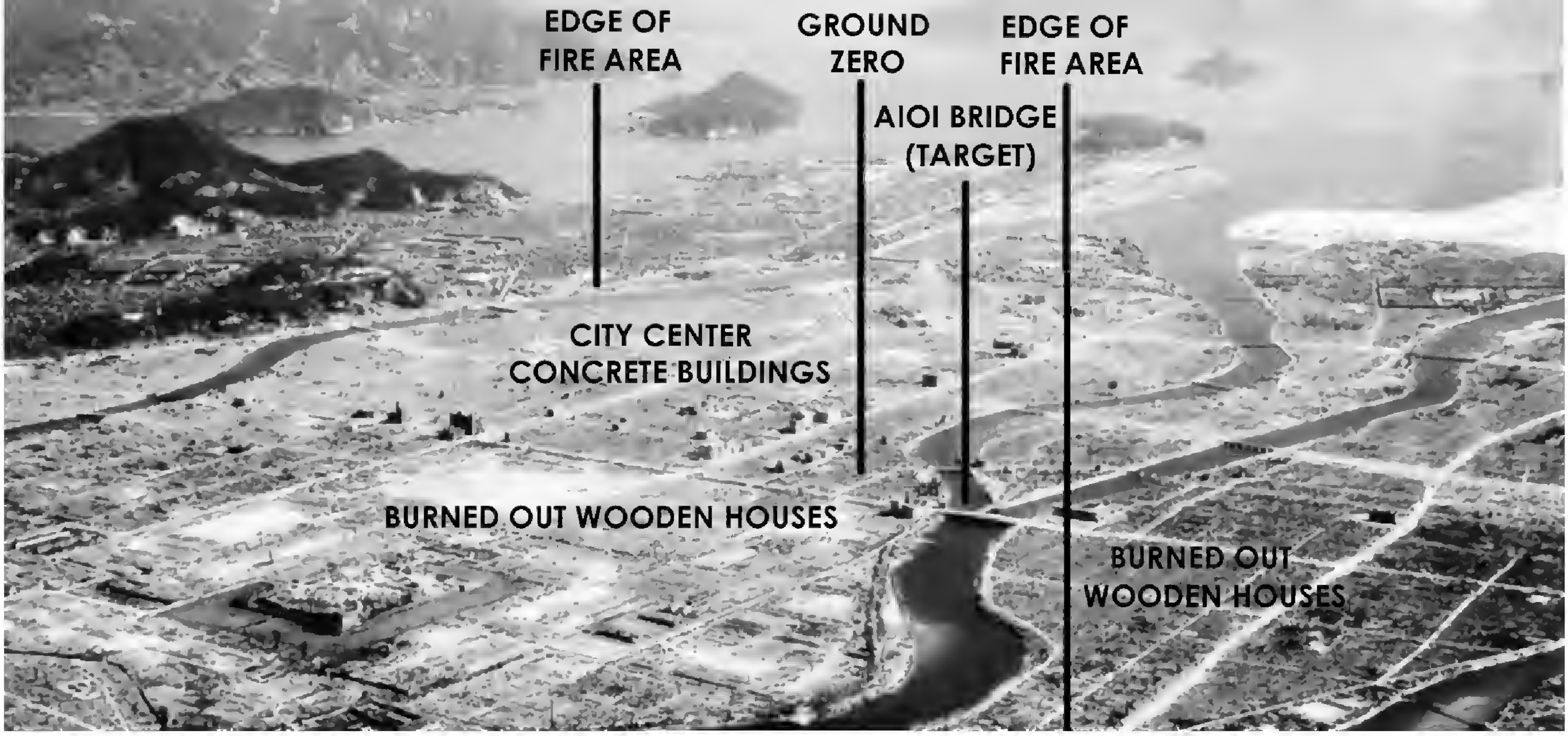
EDGE OF
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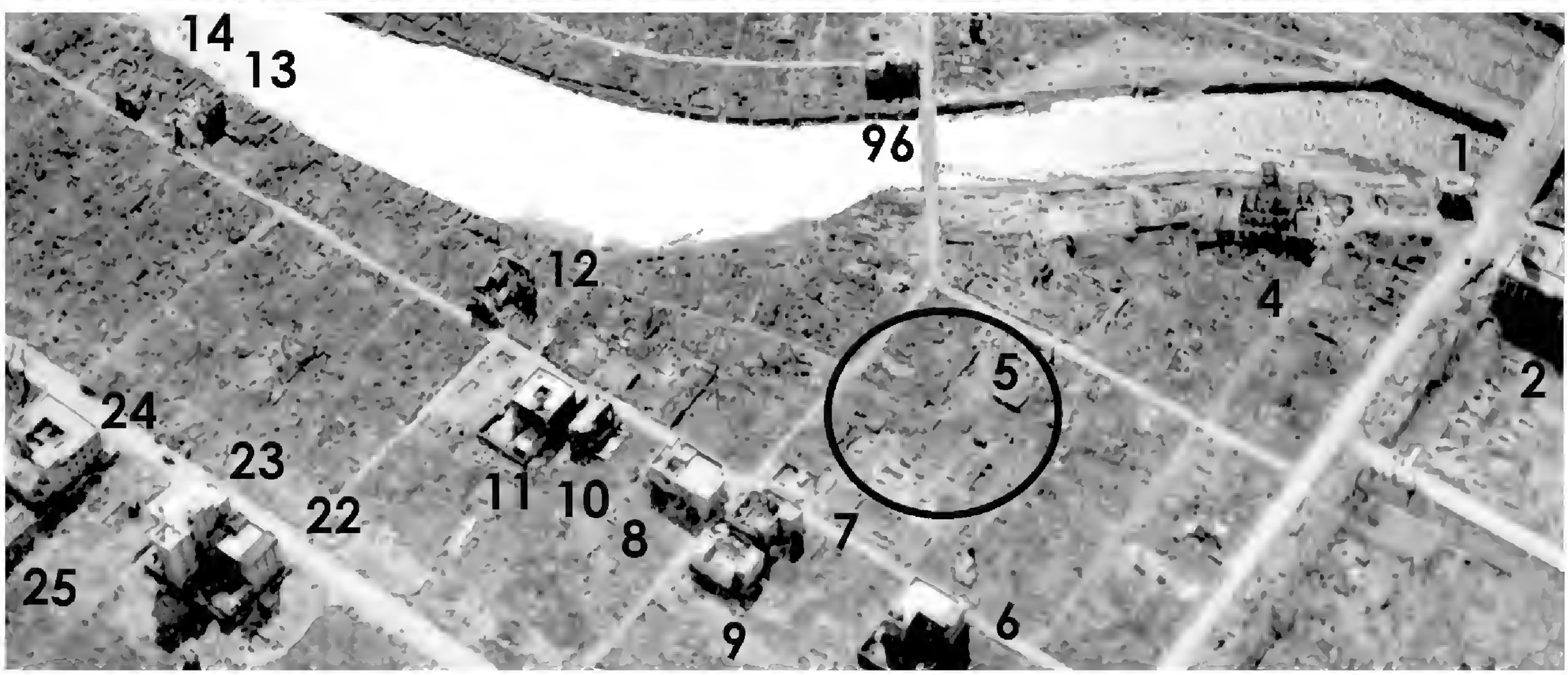
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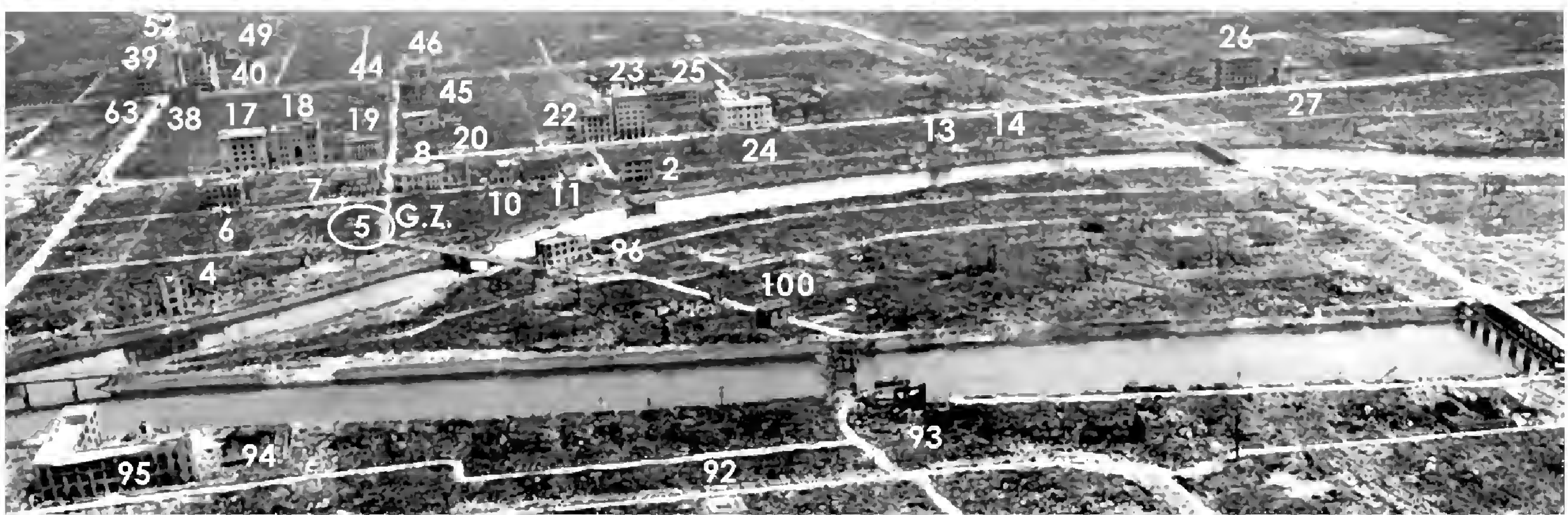
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HIROSHIMA
500 m
Hirose Grade School
HIROSE KITAMACHI
5th Transport Battalion
5th Field Artillery Regiment
Hiroshima Castle
Imperial Hq
5th Division Hq
Clothing Warehouse
11th Infantry Regiment
Military Academy
Revenue Office
6.3
TAKAJO-MACHI
SOROZAYACHO
NISHI-HIKIMIDOCHO
NISHI-KUKENCHO
Honkawa Grade School
Regimental Headquarters
NISHI DRILL FIELD
SHIN-AIOI BASHI
Steel
Electric Transformer Station
AIOI BASHI
Division Commander's Quarters
Saibi Grade School
2.64
SARUGAKUCHO
SAIKU MACHI
KAJIYA-CHO
ABURAYACHO
Canning Factory
Commercial Display Hall
NAKAJIMA-HOMMACHI
Military Police
Officers' Club
HATCHOBORI
Dept. Store
TOGIYACHO
HONKAWA BASHI
MOTOYASU BASHI
Stone
Nishio Mat Factory
NISHI-JIKATA-MACHI
TSUKAMOTOCHO
NAKAJIMA-HOMMACHI
TATEMACHI
Telephone Office
Fish Market
EBISUCHO
FIRE LANE
Saigan-ji
ZAI-MOKU-CHO
TENJIM-MACHI
ONOMICHICHO
FUKURO-MACHI
SHIN-O-HASHI
NAKAJIMA SHIMMACHI
KOBIKICHO
SHIN BASHI
Kokntai-ji
Hotel
Court of Appeals
KO-MACHI
Girls High School
SHIMONAKACHO
HORIKAWA CHO
MIKAWACHO
SHIMO-NAGARE KAWACHO
Court
Prefectural Hospital
Electric Substation
Elec Co
School for Blind and Dumb
Bank of Japan
Prefectural Office
OTEMACHI
Asano Library
Commercial School
TANAKA-MACHI
Nakajima Grade School
BANTAI BASHI
Sumori Disease Plate Factory
KOKUTAIJI MACHI
Public Hall
Daiichi Middle School
TAKEYACHO
ATHLETIC FIELD
Ote Grade School
Sanyo Middle School
Hasegawa Knitting Mill
ZAKOBACHO
TAKARAMACHI
Girls' High School
Fish Market
Commercial School
Steel
Paper Mill
MEIJI BASHI
City Hall

U. S. STRATEGIC BOMBING SURVEY

PHYSICAL DAMAGE DIVISION

Field Team No. 1, Hiroshima, Japan

BUILDING ANALYSIS

Sheet No. 1

Building No.: 24. Coordinates: 5H. Distance from (GZ): 1,300, (AZ): 2,400.

NAME: Bank of Japan, Hiroshima branch.

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame (steel core).

Number of Stories: 3 and basement. JTG class: E1.

Roof: Reinforced-concrete beam and slab.

Partitions: Reinforced concrete and wood lath.

Walls: Reinforced concrete (12-inch) and stone (6-inch).

Floors: Reinforced concrete.

Framing: Reinforced concrete.

Window and door frames: Metal (exterior) wood (interior). Ceilings: Plaster on concrete.

Condition, workmanship, and materials: Excellent.

Compare with usual United States buildings: Much stronger—steel core construction.

OCCUPANCY: Bank.

CONTENTS: Bank and office equipment furnishings.

DAMAGE to building: Only minor damage—top story burned out, partitions, sash, trim blown out in two lower stories.

Cause: Fire.

To Contents: Destroyed in third story—moderate debris and blast damage in first and second stories, none in basement.

Cause: Fire and debris (about equally).

TOTAL FLOOR AREA (square feet): 32,800. Structural damage: —. Superficial damage:

FRACTION OF DAMAGE: Building structural: —. Superficial: —. Contents: 30 percent.

REMARKS: Glass removed from skylight (20 by 20 feet) and light steel-frame structure and roof covered with 12 to 18 inches of sand and cinders.

Note.—Building damage based on total floor area. Contents damage is fraction of contents seriously damaged.

Sheet No. 2

(Fire Supplement to Sheet No. 1)

Building No.: 24. Fire classification: R.

WALL OPENINGS: Shutters: Steel rollers.

Shut: Part.

Effect of blast: Blown in.

FLOOR OPENINGS:

	Enclosed	Fire doors	Automatic	Effect of blast
Stairs:	Part	Steel rollers	No	None—doors open.
Elevators:	Yes	Metal and W. G.	No	Bent.

EXPOSURE:

Location	Distance	Firebreak Clearance	Fire Class	Burned	Remarks
N	25'	No	C	Yes	14-foot concrete wall between.
E	25'	No	R	Yes	Building 25 (14-foot wall between).
S	—	No	—	—	No exposure.
W	125'	Yes	C	Yes	

PROBABLE CAUSE OF FIRE: Fire spread from exposures.

VERTICAL FIRE SPREAD: No.

EXTENT OF FIRE: Total floor area: 32,800 square feet. Floor area burned: 5,200 square feet; 16 percent (after blast damage).

REMARKS: Fire only in room at southwest corner of second story and in entire third story. No fire in building right after bomb, but afire at 1000 hours. Fire in room in second story extinguished with water buckets.

U. S. STRATEGIC BOMBING SURVEY

PHYSICAL DAMAGE DIVISION

Field Team No. 1, Hiroshima, Japan

BUILDING ANALYSIS

Sheet No. 1

Building No.: 59. Coordinates: 5I. Distance from (GZ): 4,100, (AZ): 4,500.

NAME: Geibi Bank Co., Hiroshima Branch (in use at time of bomb as the Higashi Police Station).

CONSTRUCTION AND DESIGN

Type: Reinforced-concrete frame.

Number of stories: See sketch. JTG class: E1.

Roof: Reinforced-concrete beam and slab.

Partitions: 7-inch reinforced concrete.

Walls: 8-inch reinforced concrete monolithic—medium window.

Floors: Reinforced-concrete beam and slab—parquet and tile.

Framing: Reinforced-concrete beam and slab.

Window and door frames: Steel. Ceilings: Sheet metal on wood framing.

Condition, workmanship and materials: Good.

Compare with usual United States buildings: Appreciably stronger than United States design.

OCCUPANCY: Police station (office).

CONTENTS: Office equipment.

DAMAGE to building: Minor damage only—sash blown out and hung ceilings partially stripped.

Cause: Blast.

To contents: Slight damage to contents from blast and debris.

Cause: Blast.

TOTAL FLOOR AREA (square feet): 16,200. Structural damage: —. Superficial damage:

FRACTION OF DAMAGE: Building. Structural: Superficial: Contents: 10 percent.

REMARKS:

Note.—Building damage based on total floor area. Contents damage is fraction of contents seriously damaged.

Sheet No. 2

(Fire Supplement to Sheet No. 1)

Building No.: 59. Fire classification: R.

WALL OPENINGS: Shutters: Steel rollers in east wall and third story of south and west walls (wired glass in all windows).

Effect of blast: Blown in at west wall, bent at south wall.

FLOOR OPENINGS:

	Enclosed	Fire doors	Automatic	Effect of blast
Stairs:	Yes	Metal	No	Bent slightly.
Elevators:				

EXPOSURE:

Location	Distance	Firebreak Clearance	Fire Class	Burned	Remarks
N	150′	Yes	C	Yes	
E	60′	Yes	C	Yes	
S	30′	Partial 100′	C	Yes	All exposures burned.
W	60′	Yes	C	Yes	

PROBABLE CAUSE OF FIRE: Fire spread from exposures.

VERTICAL FIRE SPREAD: No.

EXTENT OF FIRE: Total floor area: 16,200 square feet. Floor area burned: 0 square feet; 0 percent (after blast damage).

REMARKS: Sparks from south exposure ignited few pieces of furniture in first and third stories and cotton blackout curtains in first story about 1030 hours. Fires were extinguished with water buckets by people inside. Negligible fire damage resulted. Some of exposing buildings had just been removed prior to the bomb.

 DC-P-1060-1

PREDICTION OF URBAN CASUALTIES AND THE MEDICAL LOAD FROM A HIGH-YIELD NUCLEAR BURST

L. Wayne Davis

Paper
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University Research Park
Albuquerque, New Mexico 87106

A. DEVELOPMENT OF "BLAST" MORTALITY CURVES FROM JAPANESE AND TEXAS CITY DATA

A great deal of new information has been gathered concerning the biological effects of the nuclear attacks on Hiroshima and Nagasaki, Japan, during World War II. The data from over 35,000 case histories were collected on magnetic tape, and the results of the analysis were published in DC-FR-1054 (Ref. 3).

For people in or shielded by structures in Japan, the blast and initial-nuclear radiation were the dominant immediate effects.

By examining a set of theoretical initial-nuclear-radiation mortality curves developed for Hiroshima and Nagasaki and comparing them with the total mortality curves, it could readily be seen that the initial-nuclear radiation played a large role in the deaths of thermally-shielded people located fairly close-in (at the high mortality levels) in the light structures. It is also an important effect even in the concrete structures.

By further comparing the mortality curves for Hiroshima and Nagasaki plotted as a function of overpressure (Figs. 1 and 2), it can readily be seen that the initial-nuclear radiation was more important or dominant in Hiroshima than in Nagasaki.

As another boundary condition, the Texas City mortality curves, given in Fig. 3, show the results of blast alone for a lower yield of 0.67 kt. [S.S. Grandchamp at Texas City exploded in 1947. It contained 2.3 kt of ammonium nitrate in 100-lb paper bags, but only the 0.88 kt in No. 4 hatch was tamped and exploded after catching fire. TNT equivalent was 0.67 kt.]

FIG. 1

TOTAL MORTALITY CURVES FOR HIROSHIMA

[Assumes 12.5 kt nuclear yield at 1,870 ft burst altitude; peak overpressures are about 20% greater than shown if yield is 16 kt as in the 2002 dosimetry system DS02]

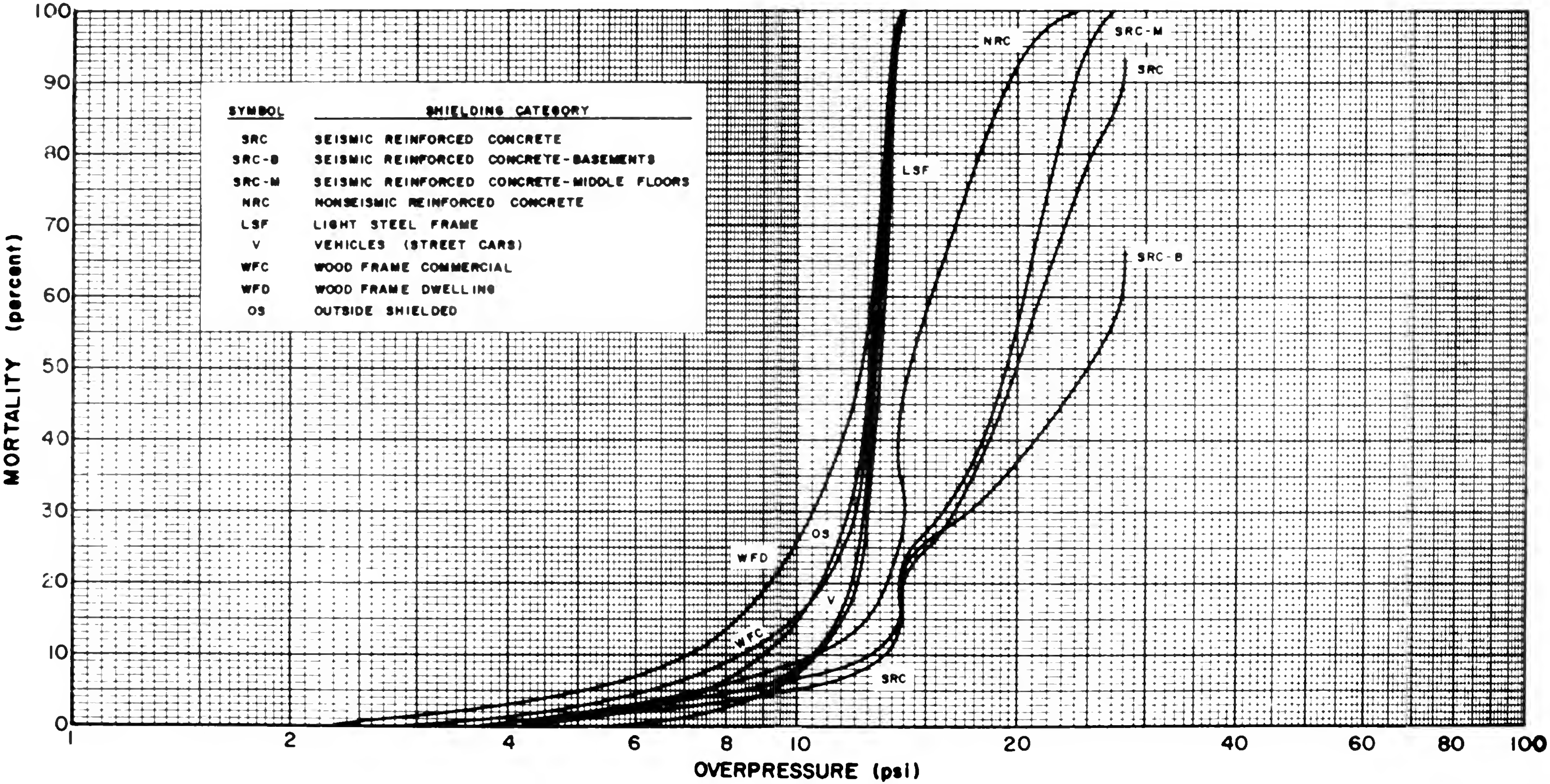


FIG. 2

TOTAL MORTALITY CURVES FOR NAGASAKI

[Assumes 22 kt nuclear yield at 1,640 ft burst altitude; peak overpressures are about 3% smaller than shown if yield is 21 kt as in the 2002 dosimetry system DS02]

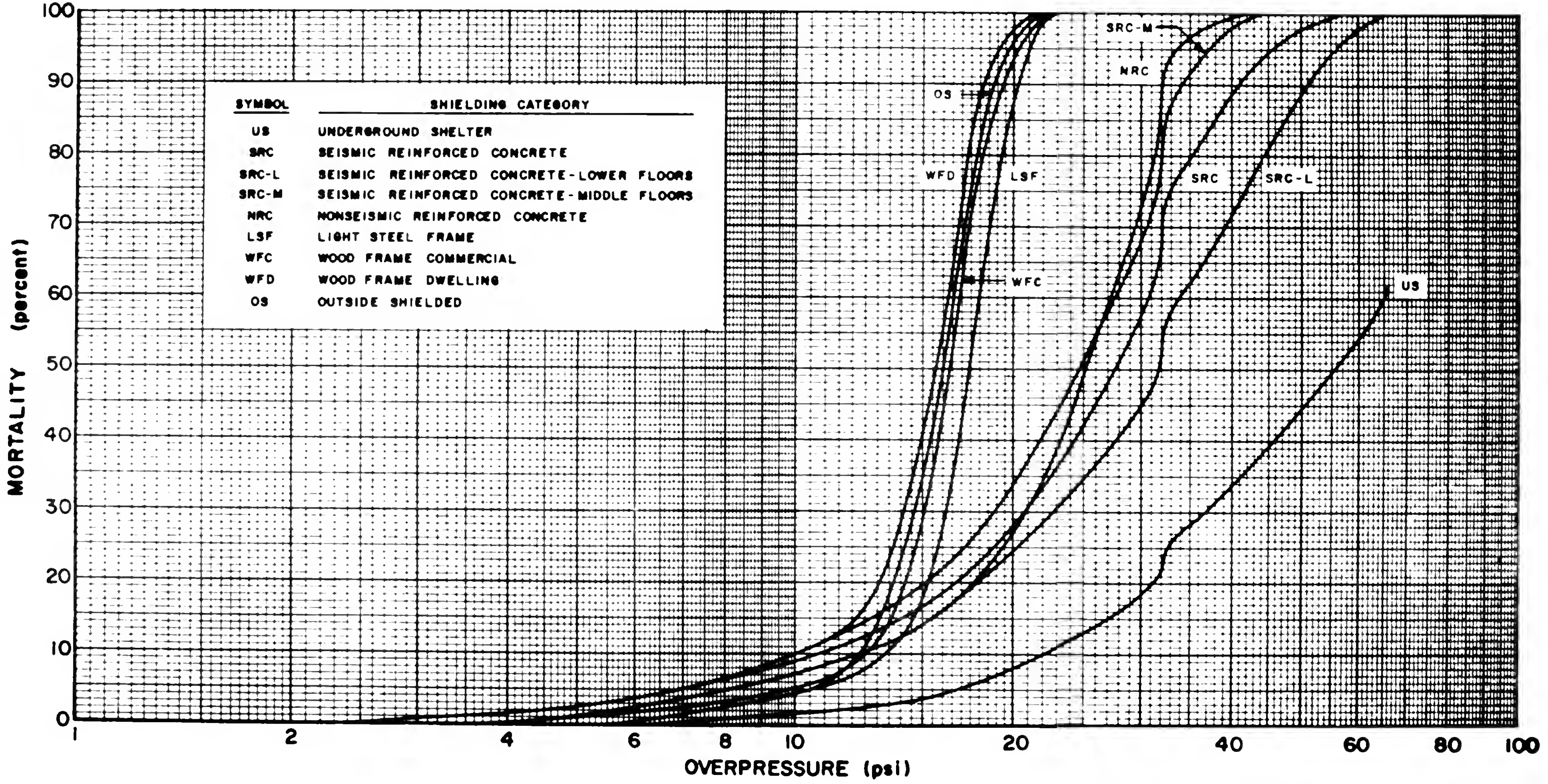


FIG. 3

TOTAL MORTALITY CURVES FOR TEXAS CITY

[0.67 kt TNT equivalent = 0.88 kt of ammonium nitrate in hatch No. 4 of S.S. Grandchamp, 1947, not the full 2.3 kt it contained. Burning debris exploded the Highflyer.]

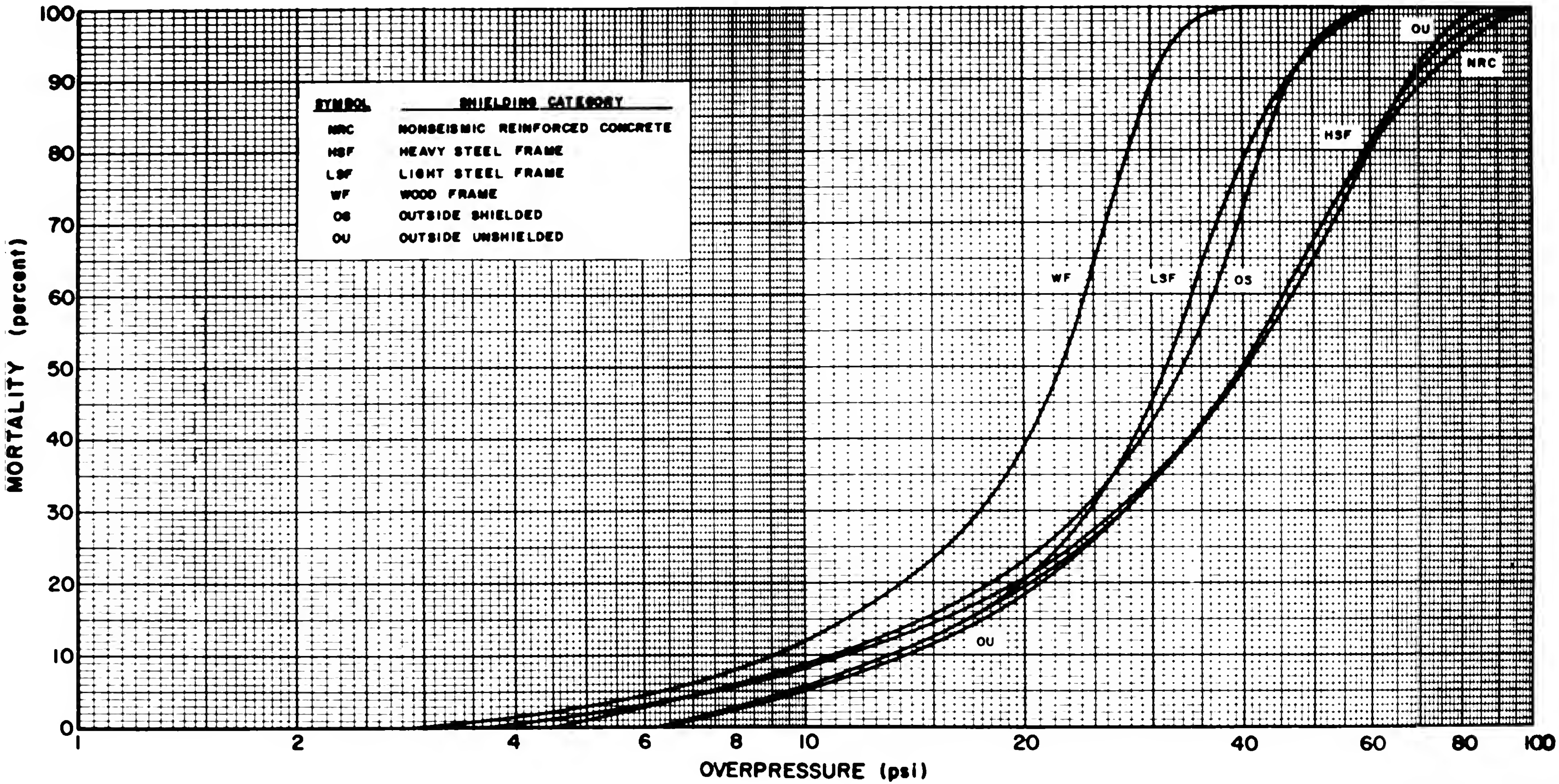


FIG. 4

BLAST MORTALITY CURVES FOR PERSONS IN OR SHIELDED BY STRUCTURES

(12.5-kt SURFACE BURST)

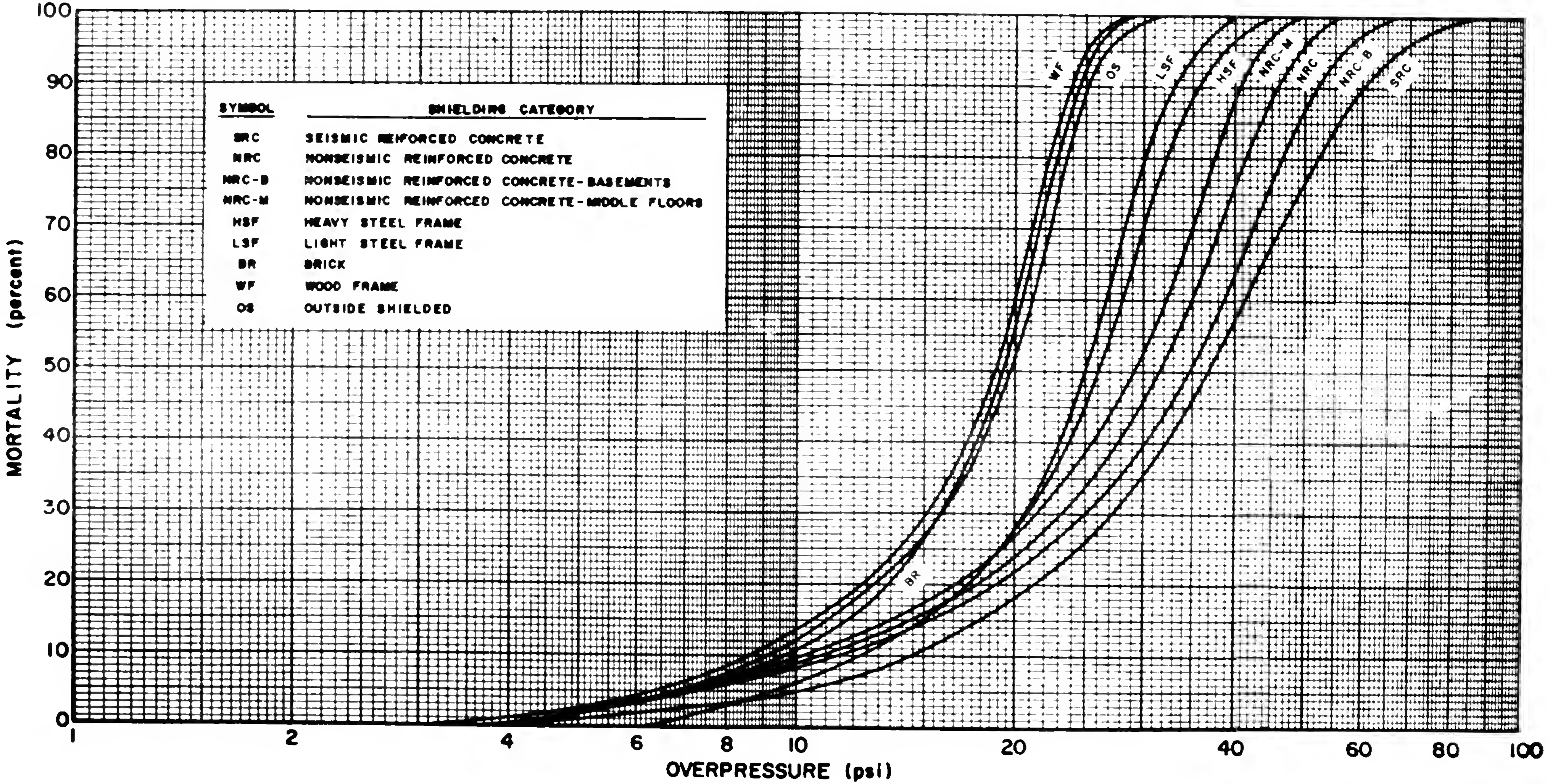


FIG. 7

TOTAL MORTALITY CURVES

FOR NONSEISMIC REINFORCED-CONCRETE BUILDINGS FROM SURFACE BURSTS

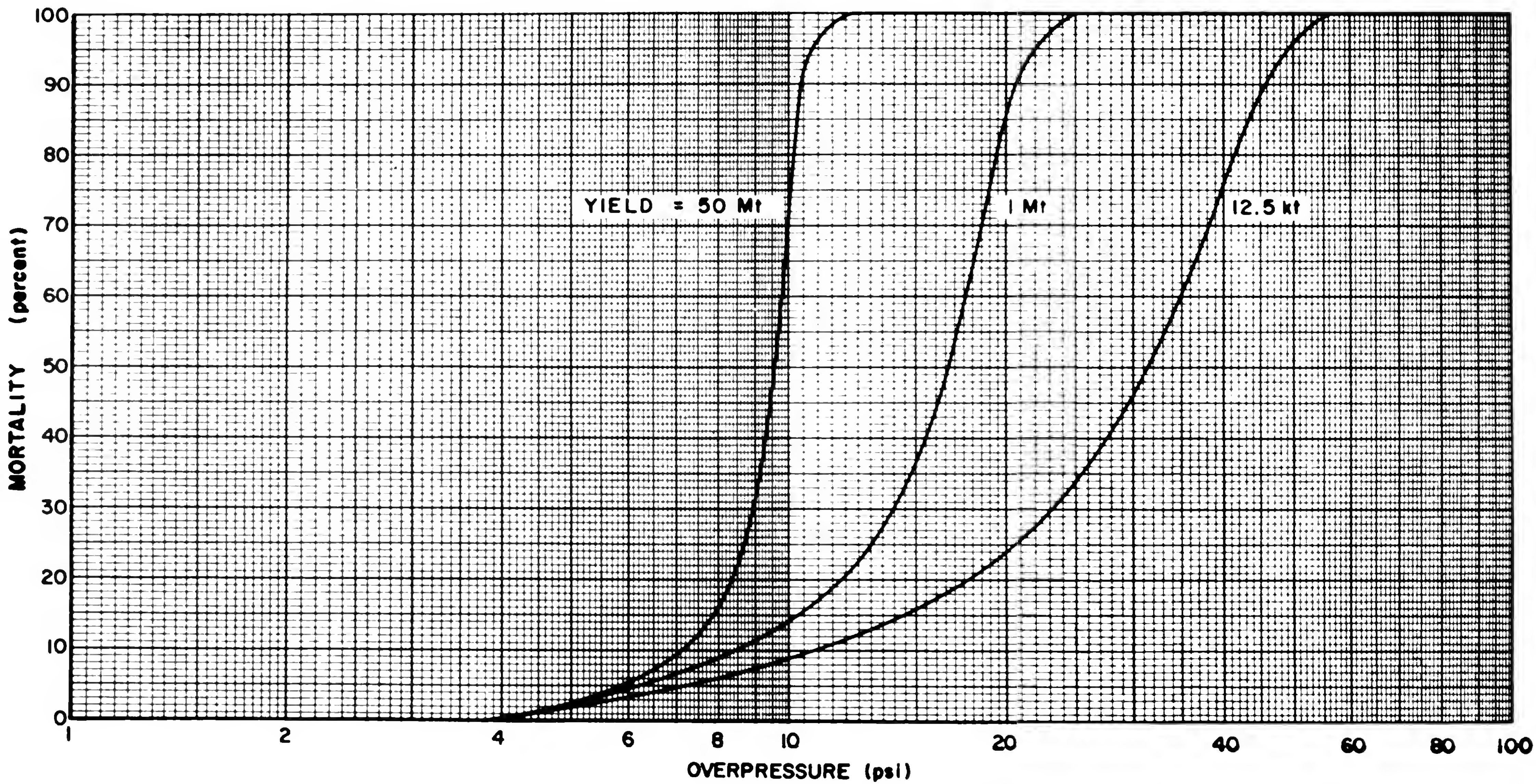


FIG. 19

PROMPT-THERMAL CASUALTY CURVES FROM A 12.5-KT SURFACE BURST FOR OUTSIDE-UNSHIELDED PERSONS

[Data based on Hiroshima assuming 12.5 kt yield. For the 2002 revised 16 kt yield in DS02, thermal exposures must be increased by 28%]

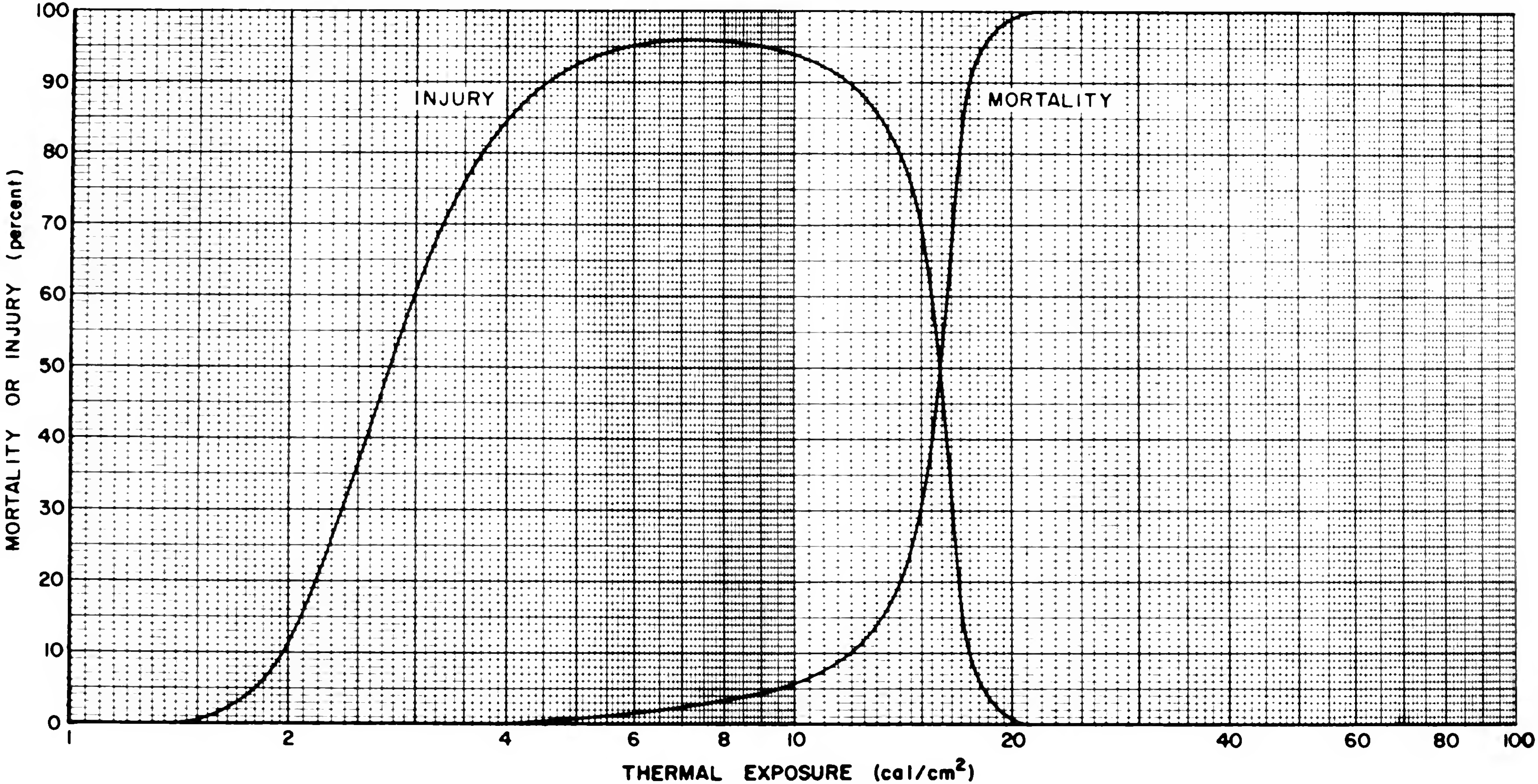


FIG. 24

PROMPT-THERMAL MORTALITY CURVES FROM SURFACE BURSTS FOR OUTSIDE-UNSHIELDED PERSONS

[Data based on Hiroshima assuming 12.5 kt yield. For the 2002 revised 16 kt yield in DS02, thermal exposures must be increased by 28%]

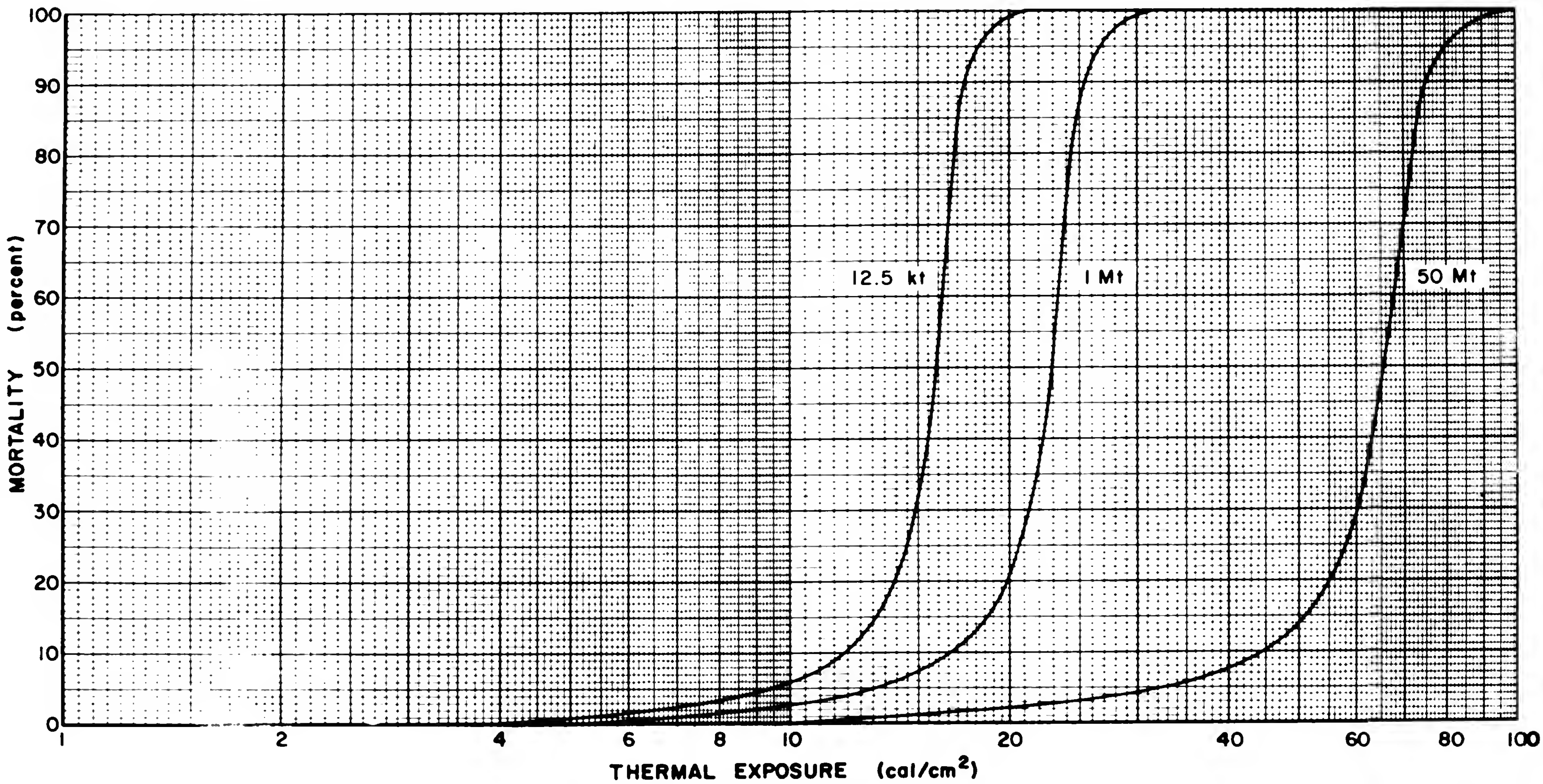
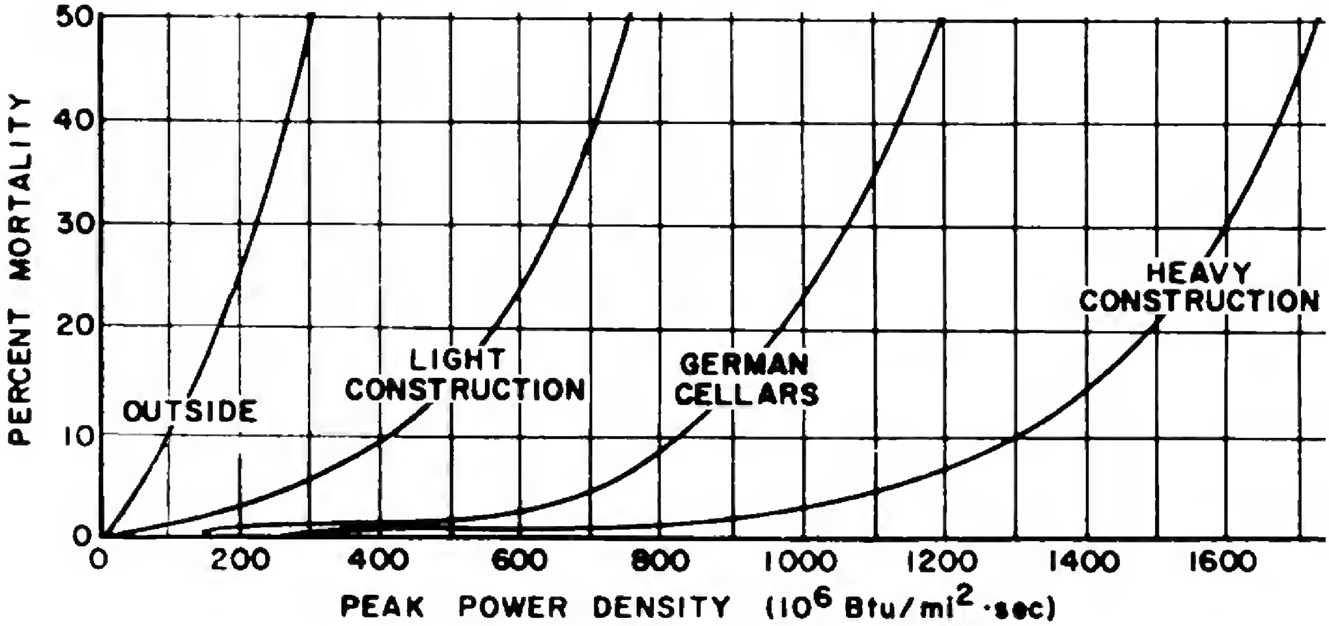
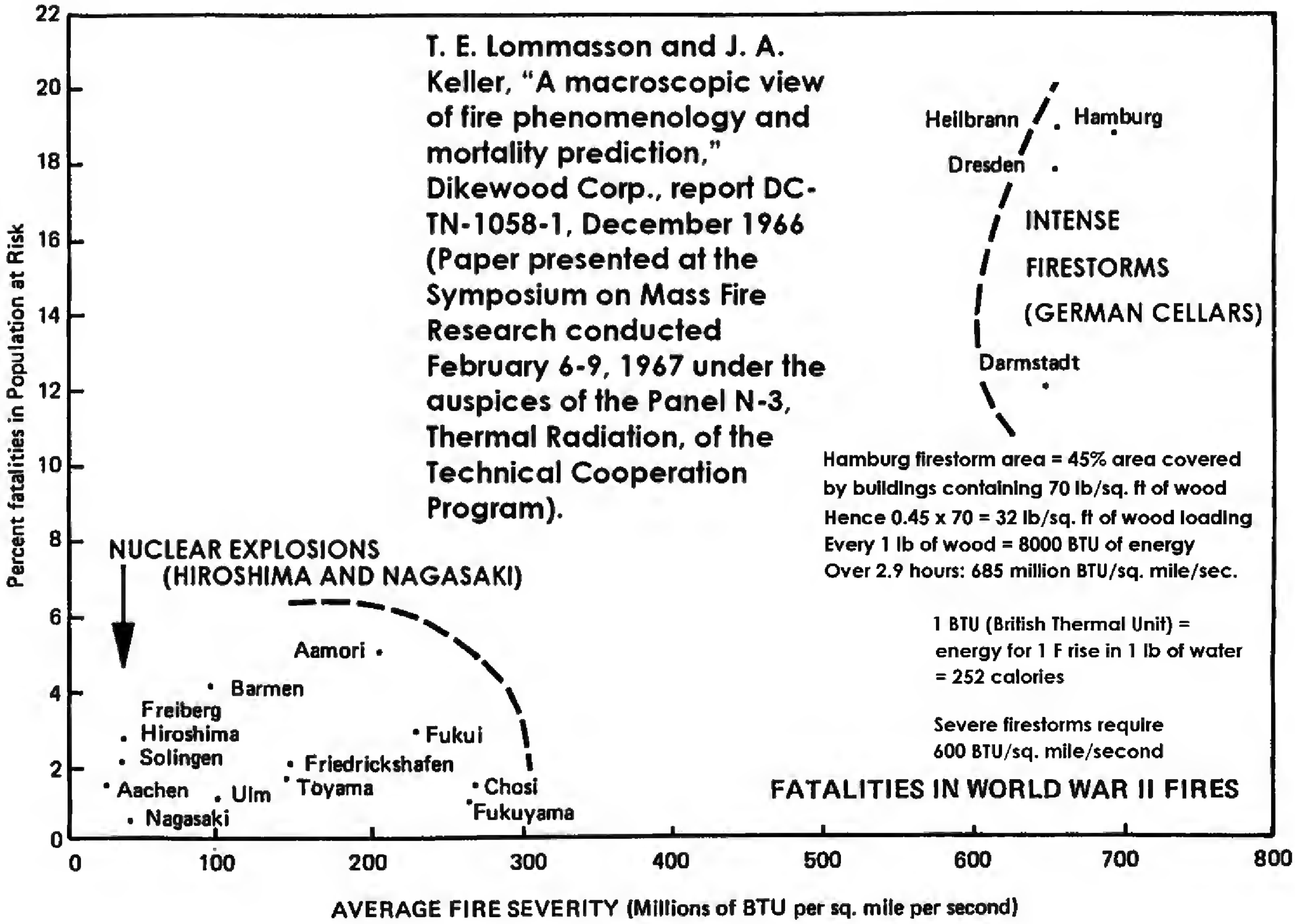


FIG. 30

FIRE MORTALITY CURVES





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MEMORANDUM
RM-3079-PR
1963

403 337

DISASTER AND RECOVERY: A HISTORICAL SURVEY

Jack Hirshleifer

PREPARED FOR:

UNITED STATES AIR FORCE PROJECT RAND

The RAND Corporation
SANTA MONICA · CALIFORNIA

As at Hamburg, people proved tougher than structures. Almost 70 per cent of the buildings in Hiroshima were destroyed, compared with around 30 per cent of population.[1]

The Research Department of the Hiroshima Municipal Office is reported to have estimated the population in the city as 407,000, in Hiroshima (Hiroshima Publishing Company, 1949).

[1]These proportions are the estimates used by the U.S. Strategic Bombing Survey report. The Hiroshima Municipal Office calculations show an even greater disparity, reporting 22 per cent of population killed and missing but some 89 per cent of buildings as destroyed or needing reconstruction (Hiroshima).

On August 7 power was generally restored to surviving areas, and through railroad service commenced on August 8. Telephone service started on August 15. Hiroshima was also not a dead city. The U.S. Strategic Bombing Survey reported that plants responsible for three-fourths of the city's industrial production could have resumed normal operations within 30 days (the newer and larger plants in Hiroshima were on the outskirts of the city, and both physical premises and personnel generally survived).[1] By mid-1949 the population had grown to over 300,000 once more, and 70 per cent of the destroyed buildings had been reconstructed.[2]

[1]USSBS, "The Effects of Atomic Bombs at Hiroshima and Nagasaki," p. 8.

[2]Hiroshima.

AIR WAR AND EMOTIONAL STRESS

Psychological Studies of Bombing and Civilian Defense

Irving L. Janis

The RAND Corporation

First Edition

NEW YORK • TORONTO • LONDON
McGRAW-HILL BOOK COMPANY, INC.
1951

CHAPTER 2
EMOTIONAL IMPACT OF THE A-BOMB

UNPREPAREDNESS OF THE POPULATION

At both Hiroshima and Nagasaki, disaster struck without warning. Whether intended so or not, an extraordinarily high degree of surprise was achieved by both A-bomb attacks. At the two target cities, prior to the bombing, there had been relatively little anxiety about the threat of heavy B-29 raids. When the planes carrying the A-bomb arrived over their targets, the population was almost completely unprepared. At the time, not even a light air raid was expected. People were caught at home, at work, out on the city streets, calmly going about their usual daily affairs.

When the first A-bomb was dropped, on August 6, 1945, very few residents of Hiroshima were inside air-raid shelters. An all-clear signal from a previous alert had sounded less than half an hour earlier and the normal routine of community life had resumed. Shortly after eight in the morning, when the explosion occurred, the working-class population was arriving at the factories and shops. Many workers were still out-of-doors en route to their jobs. The majority of school children, along with some adults from the suburbs, were also outside, hard at work building firebreaks as a defense against possible incendiary raids. Housewives, especially in middle-class families, were at home, preparing breakfast. Only a few minutes later, their flaming charcoal stoves were to create hundreds of local fires, adding to a general conflagration of such intensity that even if the assiduous labor of Hiroshima's school children had been completed, the fire storm still would have been beyond control.

At Nagasaki, three days later, the populace had heard only vague reports about the Hiroshima disaster. Here again, people were at

work in factories and offices, tending their homes, engaging in their normal daily activities. A few hours earlier a raid alert had been canceled; before the raid signal could be repeated, the bomb had already exploded. Only 400 people out of a population of close to a quarter of a million were inside the excellent tunnel shelters that could have protected some 75,000 people from severe injury or death.

It is generally recognized that the element of surprise was an important factor contributing to the unprecedented casualty rates at Hiroshima and Nagasaki. Many of those who were exposed to lethal gamma radiation, struck down by flying debris, or trapped in collapsed buildings would not have been killed if they had been warned in time to flee to the outskirts of the city or if they had been in adequate shelters. Thousands of people who were out-of-doors or standing in front of windows would have been protected from incapacitating flash burns if they had been under any sort of cover.[1]

Whether or not they suffered severe injury, those who survived the explosion were also affected by the element of surprise in quite another way. The absence of warning and the generally unprepared state of the population undoubtedly augmented the emotional effects of the disaster. "I was just utterly surprised and amazed and awed." This brief remark, by a newspaper reporter who was living in Nagasaki at the time of the disaster, epitomizes the way in which survivors described the terrifying events to which they were so suddenly exposed.

Of great importance in the predispositional set of the population is the fact that there was not a state of readiness to face danger or to cope with the harsh exigencies of a major catastrophe. The stage was well set for extreme emotional responses to dominate the action. It is against this background of psychological unpreparedness that the emotional impact resulting from the atomic disasters should be viewed.

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[1] USSBS Report, *The Effects of Atomic Bombs on Hiroshima and Nagasaki*, U.S. Government Printing Office, Washington, D.C., 1946.

The Effects of

Nuclear Weapons

SAMUEL GLASSTONE

Editor

Revised Edition
Reprinted February 1964

Prepared by the

UNITED STATES DEPARTMENT OF DEFENSE

Published by the

UNITED STATES ATOMIC ENERGY COMMISSION

April 1962

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C. - Price $3.00 (paper bound)

Foreword

This book is a revision of "The Effects of Nuclear Weapons" which was issued in 1957. It was prepared by the Defense Atomic Support Agency of the Department of Defense in coordination with other cognizant governmental agencies and was published by the U.S. Atomic Energy Commission. Although the complex nature of nuclear weapons effects does not always allow exact evaluation, the conclusions reached herein represent the combined judgment of a number of the most competent scientists working on the problem.

There is a need for widespread public understanding of the best information available on the effects of nuclear weapons. The purpose of this book is to present as accurately as possible, within the limits of national security, a comprehensive summary of this information.

Secretary of Defense

Chairman
Atomic Energy Commission

12.11 In Japan, where little evasive action was taken, the survival probability depended upon whether the individual was outdoors or inside a building and, in the latter case, upon the type of structure. At distances between 0.3 and 0.4 mile (530 and 700 yards) from ground zero in Hiroshima the average survival rate, for at least 20 days after the nuclear explosion, was less than 20 percent. Yet in two reinforced-concrete office buildings, at these distances, almost 90 percent of the nearly 800 occupants survived more than 20 days, although some died later from radiation injury.

These facts bring out clearly the greatly improved chances of survival from a nuclear explosion that could result from the adoption of suitable warning and protective measures.

TABLE 12.29—ARRIVAL TIME FOR PEAK OVERPRESSURE

Distance (miles)	Explosion yield				
	1 KT	*10 KT*	*100 KT*	*1 MT*	*10 MT*
	(Time in seconds)				
1	4. 3	3. 6	3. 7	2. 5	1. 5
2	9	8. 1	7. 4	6. 5	5. 0

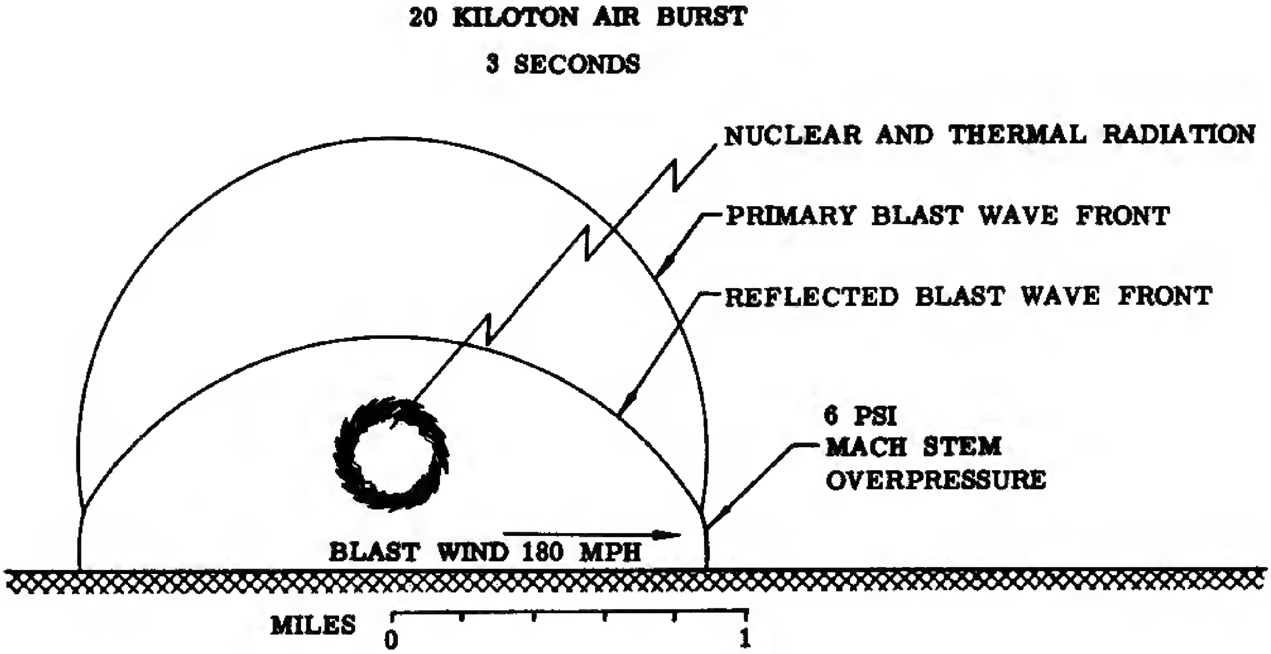
12.35. The major part of the thermal radiation travels in straight lines, and so any opaque object interposed between the fireball and the exposed skin will give some protection. This is true even if the object is subsequently destroyed by the blast, since the main thermal radiation pulse is over before the arrival of the blast wave.

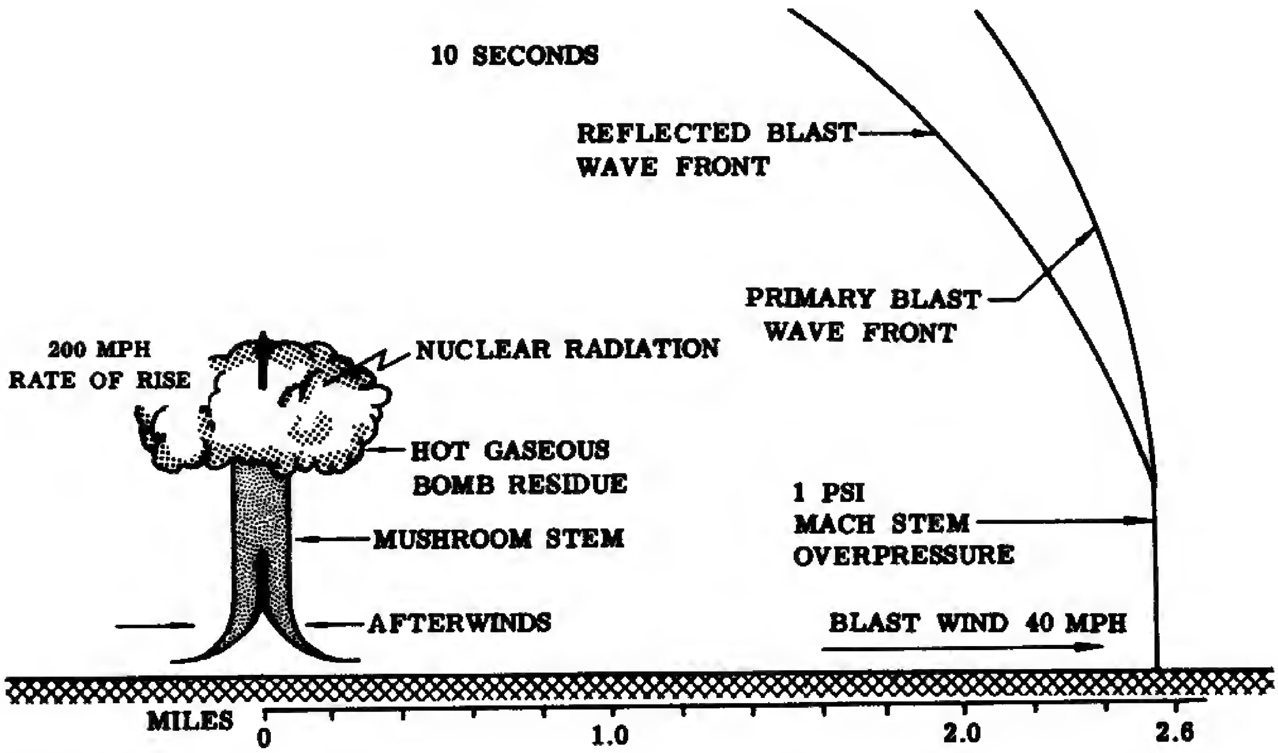
12.36 At the first indication of a nuclear explosion, by a sudden increase in the general illumination, a person inside a building should immediately fall prone, as described in § 12.30, and, if possible, crawl behind or beneath a table or desk or to a planned vantage point.

12. 72 Because of its particulate nature, fallout will tend to collect on horizontal surfaces, e.g., roofs, streets, tops of vehicles, and the ground. In the preliminary decontamination, therefore, the main effort should be directed toward cleaning such surfaces. The simplest way of achieving this is by water washing, if an adequate supply of water is available. The addition of a commercial wetting agent (detergent) will make the washing more efficient. The radioactive material is thus tranferred to storm sewers where it is less of a hazard.

S. Glasstone, Effects of Nuclear Weapons, 1962:

Explosion yield	*Height of burst (feet)*	*Time after detonation (seconds)*	*Distance from ground zero (miles)*	*Height of stem (feet)*
20 kilotons	1, 760	3	0. 87	185
1 megaton	6, 500	11	3. 2	680

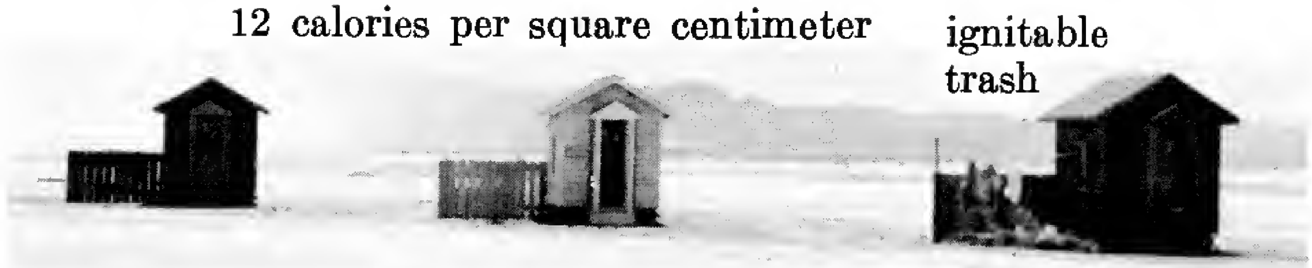




At 10 seconds after a 20-kiloton explosion at an altitude of 1,760 feet the Mach front is over 2½ miles from ground zero, and 37 seconds after a 1-megaton detonation at 6,500 feet, it is nearly 9½ miles from ground zero. The overpressure at the front is roughly 1 pound per square inch, in both cases, and the wind velocity behind the front is 40 miles per hour.

Nevada in 1953.

12 calories per square centimeter



before exposure to a nuclear explosion

after exposure to a nuclear explosion

7.59 The value of fire-resistive furnishing in decreasing the number of ignition points was also demonstrated in the tests. Two identical, sturdily constructed houses, each having a window 4 feet by 6 feet facing the point of burst, were erected where the thermal radiation exposure was 17 calories per square centimeter. One of the houses contained rayon drapery, cotton rugs, and clothing, and, as was expected, it burst into flame immediately after the explosion and burned completely. In the other house, the draperies were of vinyl plastic, and rugs and clothing were made of wool. Although much ignition occurred, the recovery party, entering an hour after the explosion, was able to extinguish the fires.

7.76 It should be noted that the fire storm is by no means a special characteristic of nuclear weapons. Similar fire storms have been reported as accompanying large forest fires in the United States, and especially after incendiary bomb attacks in both Germany and Japan during World War II. The high winds are produced largely by the updraft of the heated air over an extensive burning area. They are thus the equivalent, on a very large scale, of the draft of a chimney under which a fire is burning. Because of limited experience, the conditions for the development of fire storms in cities are not well known. It appears, however, that some, although not necessarily all, of the essential requirements are the following: (1) thousands of nearly simultaneous ignitions over an area of at least a square mile, (2) heavy building density, e.g., more than 20 percent of the area is covered by buildings, and (3) little or no ground wind. Based on these criteria, only certain sections—usually the older and slum areas—of a very few cities in the United States would be susceptible to fire storm development.

Weapon test report WT-775, Project 8.11b, ENCORE nuclear test, Nevada, 1953:

6' x 6' wood frame houses

CONFIDENTIAL

WT-774

Copy No. 186 A

Operation UPSHOT-KNOTHOLE

NEVADA PROVING GROUNDS

March - June 1953

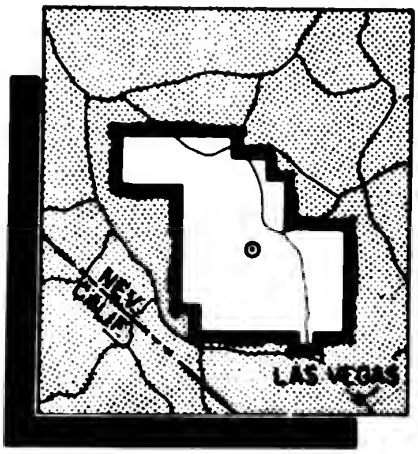
Project 8.11a

INCENDIARY EFFECTS ON BUILDING AND INTERIOR KINDLING FUELS

(<u>ENCORE EFFECT REPORT</u>)

27 kt at 2,423 feet altitude, <u>19% humidity</u>

(DASA-1251) (Note: cities humidity is ~50-80%)



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HEADQUARTERS FIELD COMMAND, ARMED FORCES SPECIAL WEAPONS PROJECT
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

CONFIDENTIAL

Weapon test report WT-774, Project 8.11a, Incendiary effects on buildings and interior kindling fuels

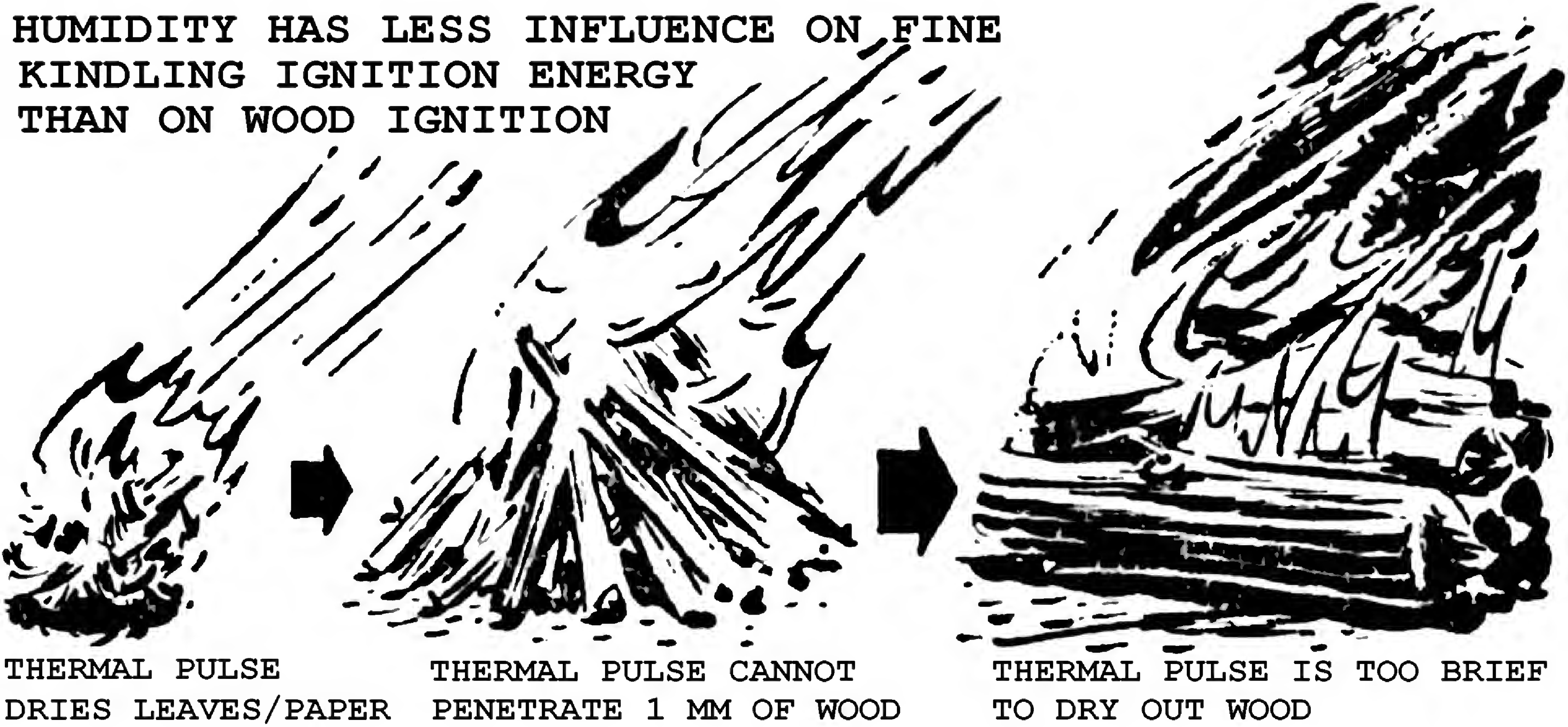
ENCORE test, Nevada, 1953
10' x 12' wooden houses with 4' x 6' windows
17 calories/sq. cm thermal flash

Immediate room flashover during thermal pulse
("Encore effect") in inflammables-filled house
while fire-resistant fabrics in other house survived!

LEFT HOUSE: fire-resistant furnishings
(woolen rugs and clothes, vinyl plastic draperies)

RIGHT HOUSE: non-fire resistant furnishings
plus inflammable magazines and newspapers

Smouldering armchair extinguished 1 hour after detonation, when recovery party arrived at house


HUMIDITY HAS LESS INFLUENCE ON FINE
KINDLING IGNITION ENERGY
THAN ON WOOD IGNITION
THERMAL PULSE
DRIES LEAVES/PAPER
THERMAL PULSE CANNOT
PENETRATE 1 MM OF WOOD
THERMAL PULSE IS TOO BRIEF
TO DRY OUT WOOD

EFFECTS OF 1 PSI OVERPRESSURE ON IGNITIONS
From: Goodale, Effects of Air Blast on Urban Fires
URS 7009–14 Dec. 1970
(AD 723 429)

Blast winds both cool burning material and upset flame convection system.

50% of burning curtains are extinguished by 1 psi overpressure

100% are put out by 2.5 psi. Note that burning LIQUIDS in high-wall trays are not put out by blast waves, but this is not relevant to city fires.

Burning beds can continue to smoulder until extinguished with water.

We have all had the frustrating experience of trying to light a fire with green, moist, or wet wood. Just as wet wood can't be easily induced to burn, so thick combustibles are not easily ignited. Even a dry two-by-four burns reluctantly and stops burning when taken out of the fire. It is a different matter with a shingle or a bunch of kindling! Density also plays a role, a heavier combustible being harder to ignite than lighter-weight material. Of course, the chemistry of the material to the degree that it influences kindling temperatures and flammability, is an important parameter. Modern plastics tend to smoke and boil - to ablate but not to ignite in sustained burning - while paper trash burns readily.

Just as most materials are not particularly sensitive to the sun's thermal radiation, and are not highly inflammable nor even ignitible, the surfaces exposed to the thermal intensity of a nuclear explosion are generally not given to sustained burning. Very intense heat loads may mar or melt surfaces, may char and burn surfaces while the heat is on, but may snuff out immediately afterward.

PRIMARY AND SECONDARY FIRES FROM NUCLEAR EXPLOSIONS

Although thermal radiation would start many fires in urban and in most suburban areas, such fires by themselves would seldom constitute a source of major destruction. Outside the region of extensive blast damage, fires in trash piles, in dry palm trunks, in roof shingles, in auto and household upholstery, drapes, or flammable stores are normally accessible and readily controllable. By the very fact that these fires start from material exposed to the incident light, they can be easily spotted and, in the absence of other distractions, can be quickly extinguished. Where the blast effects are severe and damage extensive, little effective fire fighting is likely.

A SURVEY OF THE WEAPONS AND HAZARDS WHICH MAY FACE THE PEOPLE OF THE UNITED STATES IN WARTIME

Harold L. Brode

P-3170

June 1965

Most exposed surfaces in the city are non-combustible and much of the remainder is not ignitable by thermal flash. Although many fires could simultaneously start wherever building interiors are illuminated by the bomb thermal energy, they are not likely to be immediately beyond control, and will often go out unattended as they exhaust the available fuel (as in trash barrels or isolated wood piles or even pieces of paper on tables or floors).

Hanging non-flammable shields over window openings and removing likely fuels from exposed positions could also help.

RAND CORPORATION

HIROSHIMA

John Hersey

NEW YORKER *of* 31 *August*, 1946

I

A NOISELESS FLASH

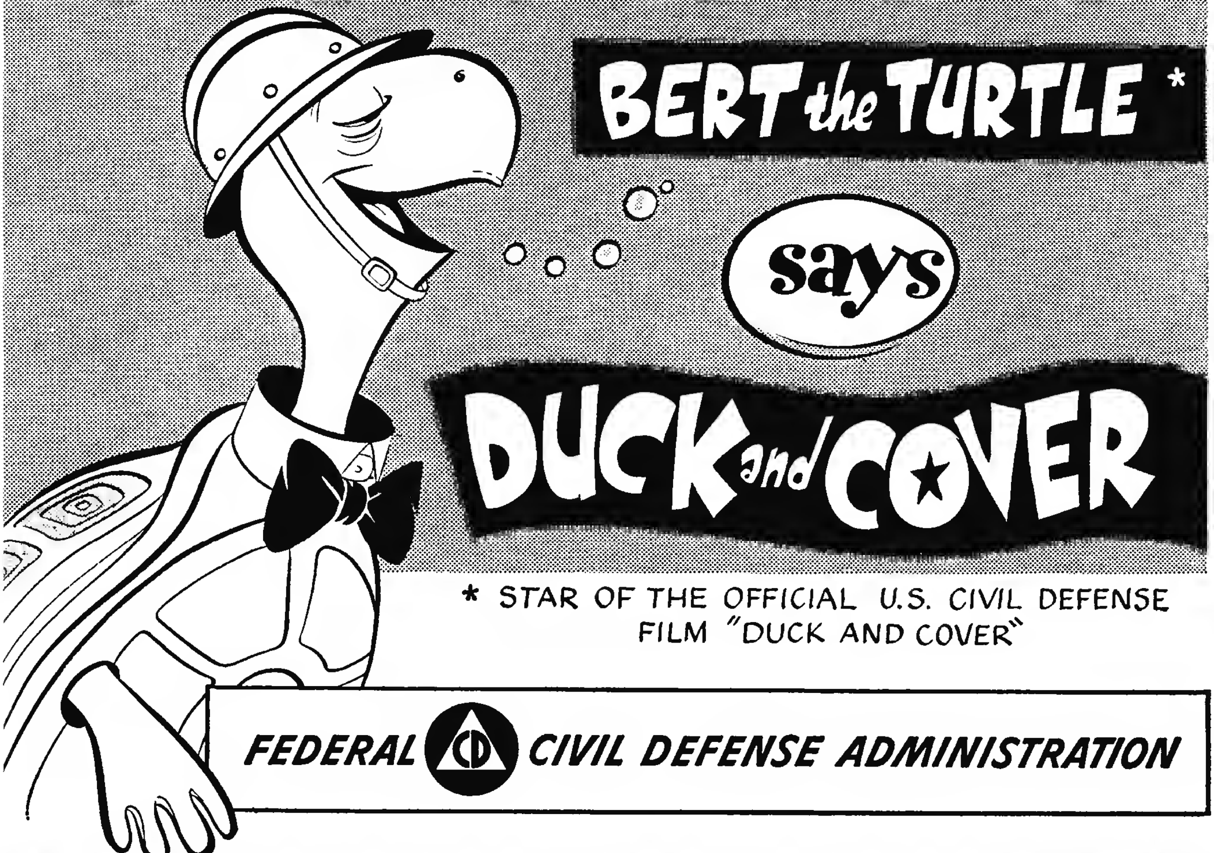
AT exactly fifteen minutes past eight in the morning, on August 6th, 1945, Japanese time, at the moment when the atomic bomb flashed above Hiroshima,

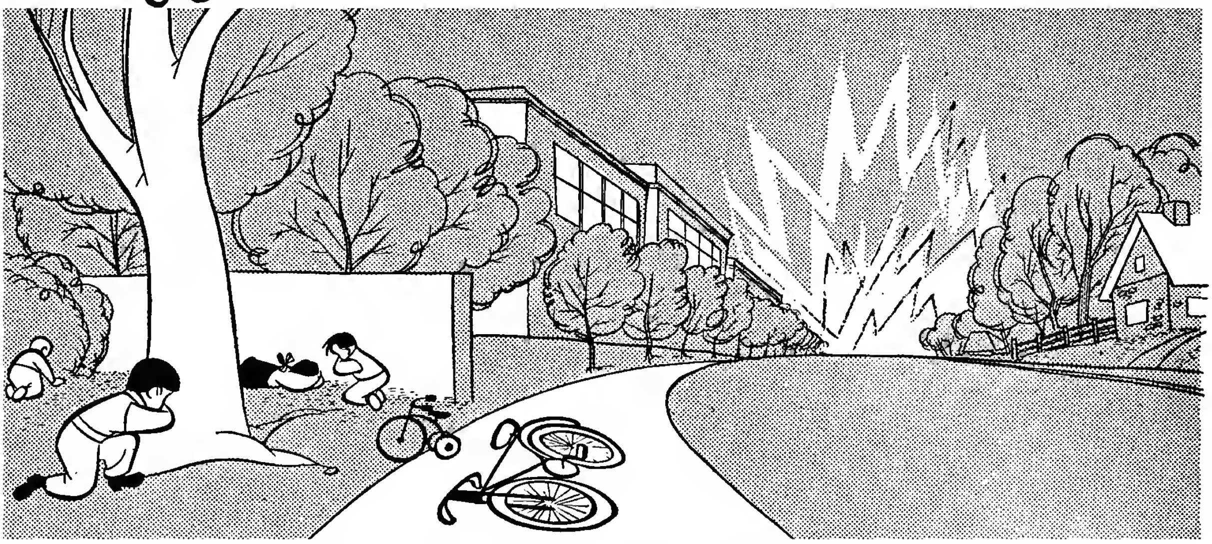
Dr. Terufumi Sasaki, a young member of the surgical staff of the city's large, modern Red Cross Hospital, walked along one of the hospital corridors

He was one step beyond an open window when the light of the bomb was reflected, like a gigantic photographic flash, in the corridor. He ducked down on one knee and said to himself, as only a Japanese would, "Sasaki, *gambare !* Be brave !" Just then (the building was 1,650 yards from the centre), the blast ripped through the hospital. The glasses he was wearing flew off his face; the bottle of blood crashed against one wall; his Japanese slippers zipped out from under his feet—but otherwise, thanks to where he stood, he was untouched.

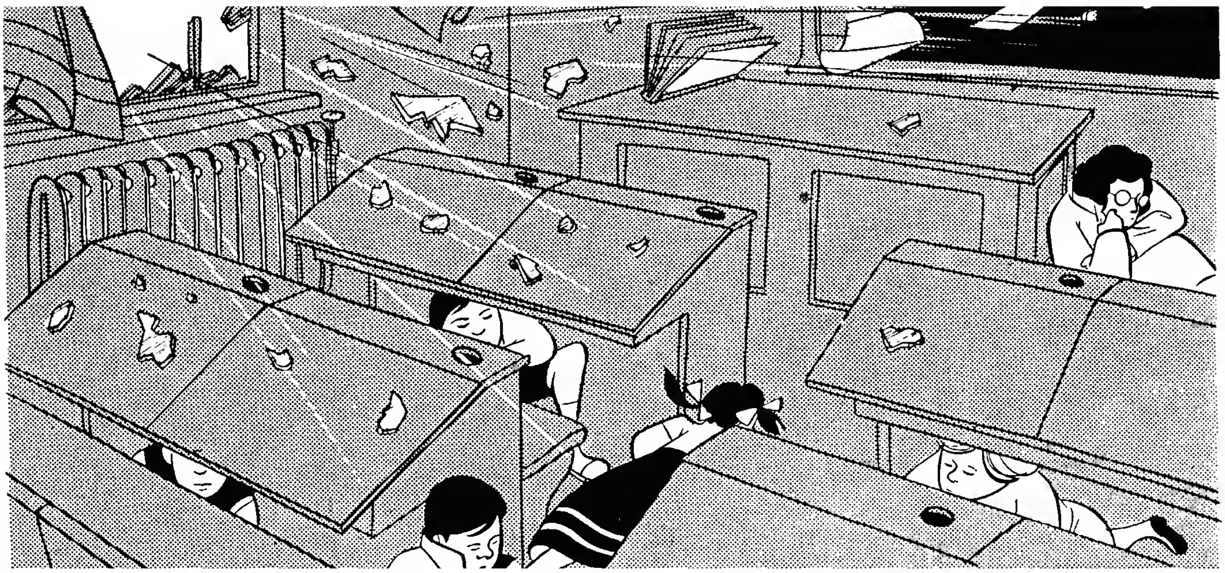
Dr. Sasaki shouted the name of the chief surgeon and rushed around to the man's office and found him terribly cut by glass.

Starting east and west from the actual centre, the scientists, in early September, made new measurements, and the highest radiation they found this time was 3.9 times the natural "leak."





SO, LIKE BERT, YOU **DUCK** TO AVOID THE THINGS FLYING THROUGH THE AIR...



...AND **COVER** TO KEEP FROM GETTING CUT OR EVEN BADLY BURNED.

AIR WAR AND EMOTIONAL STRESS

Psychological Studies of Bombing and Civilian Defense

Irving L. Janis
The RAND Corporation

1951

Time from flash to blast = 4 sec at 1 mile:

A substantial proportion of the respondents in Hiroshima and Nagasaki reported having reacted immediately to the intense flash alone, as though it were a well-known danger signal, despite the fact that they were unaware of its significance at the time. A number of them said that they voluntarily ducked down or "hit the ground" as soon as the flash occurred and had already reached the prone position before the blast swept over them.

From the above discussion, it is apparent that some of the survivors immediately perceived the flash as a danger signal. It also appears that for those who were not located near the center there was an opportunity to take protective action that could reduce injuries from the secondary heat wave and from flying glass, falling debris, and other blast effects. It is noteworthy that some survivors evidently failed to make use of this opportunity, as is to be expected when there has been no prior preparation for it.

In a later chapter on the problems of civil defense, we shall have occasion to take account of these findings, since they suggest that casualties in an A-bomb attack might be reduced if the population has been well prepared in advance to react appropriately to the flash of the explosion.

AD A105824 DNA 5593T

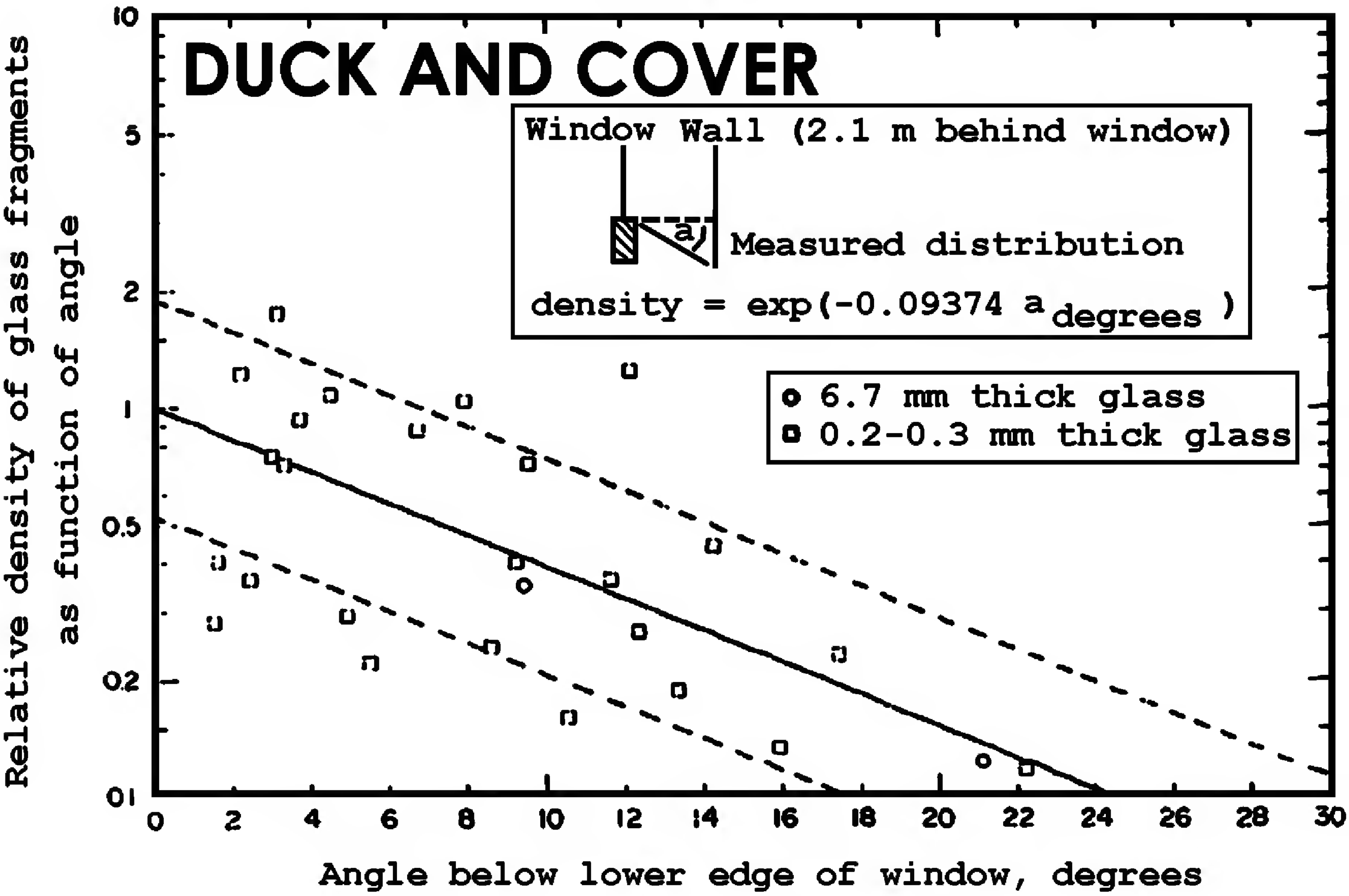
GLASS FRAGMENT HAZARD FROM WINDOWS BROKEN BY AIRBLAST

E. Royce Fletcher

Flying glass injured to 3.2 km in Hiroshima, 3.8 km in Nagasaki. 3.2 mm thick window glass fragments striking walls 2.1 m behind the windows in nuclear and high explosive tests gave:

10 fragments/m^2 for 6.3 kPa (0.9 psi) overpressure
100 fragments/m^2 for 29 kPa (4.2 psi) overpressure
1,000 fragments/m^2 for 65 kPa (9.4 psi) overpressure

Figure 10



AECU-3350

UNITED STATES ATOMIC ENERGY COMMISSION

BIOLOGICAL EFFECTS OF BLAST FROM BOMBS. GLASS FRAGMENTS AS PENETRATING MISSILES AND SOME OF THE BIOLOGICAL IMPLICATIONS OF GLASS FRAGMENTED BY ATOMIC EXPLOSIONS

By
I. Gerald Bowen
Donald R. Richmond
Mead B. Wetherbe
Clayton S. White

Table 5.1 Statistical Parameters and Predicted Penetration Data for Missiles from Traps at Various Ranges from Ground Zero

30 kt TEAPOT-APPLE 2 nuclear test, 1955

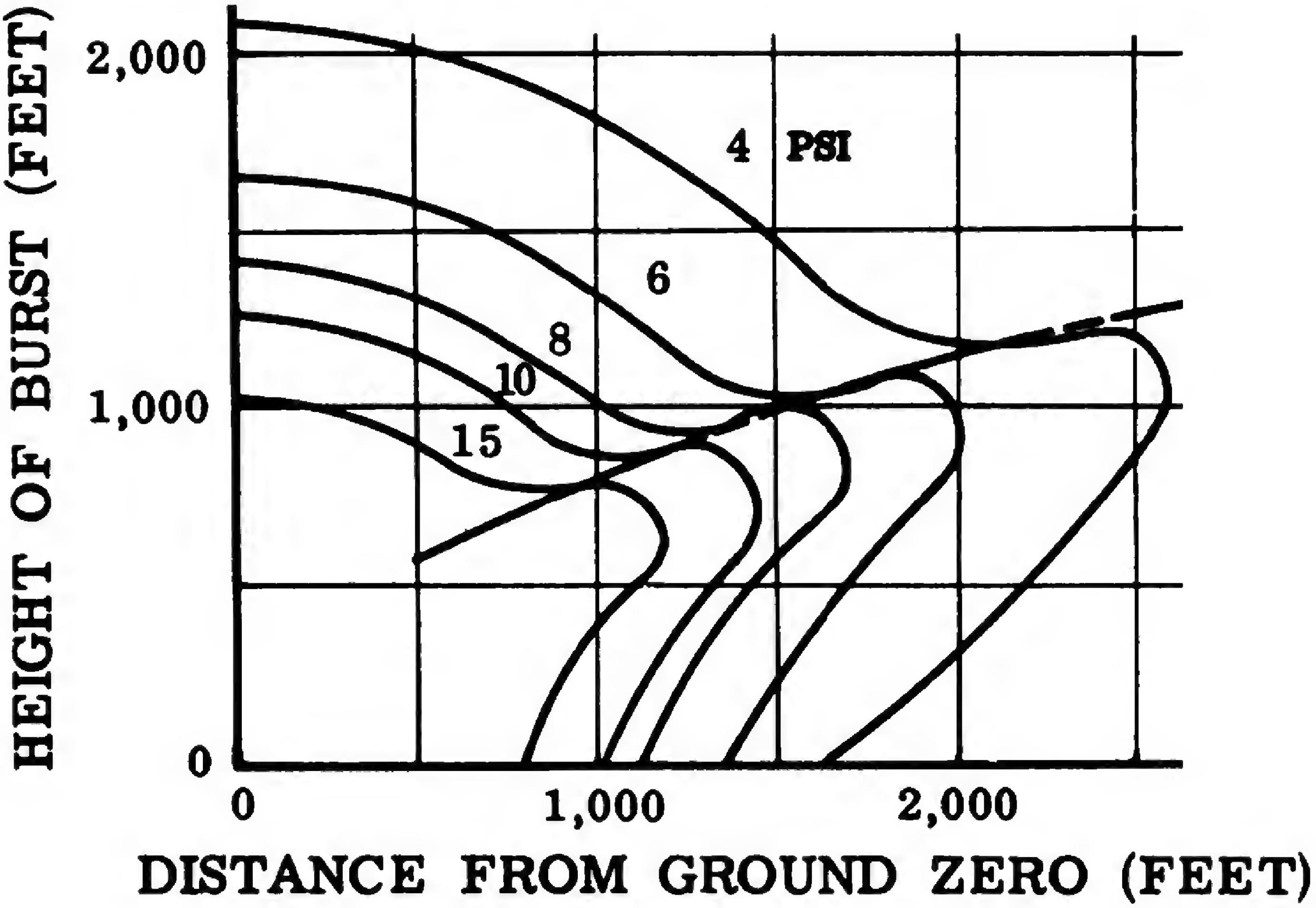
Distance from Ground Zero, ft	4,700	5,500	10,500
Maximum overpressure, psi	5.0	3.8	1.9
Number of traps	6	2	5
Total number of glass missiles	2129	320	37
Geometric mean missiles mass, gms	0.133	0.580	1.25
Standard geometric deviation in mass	3.01	3.47	3.35
Geometric mean missile velocity, ft/sec	170	168	103
Standard geometric deviation in velocity	1.27	1.25	1.25
Per cent of total missiles expected to penetrate	3.9*	12.8*	0.4*
Average number of missiles per sq ft	100.9	45.5	2.1
Missiles per sq ft expected to penetrate	3.9*	5.3*	0.006*

*Computed from individual evaluation of each missile

The Effects of Nuclear Weapons (1964)

GLASS

Peak overpressure (psi)	*Median velocity (ft/sec)*	*Median mass (grams)*	*Maximum number per sq ft*
1. 9	108	1. 45	4. 3
5. 0	170	0. 13	388



Peak overpressures on the ground for 1-kiloton burst

GLASS PENETRATING ABDOMINAL CAVITY

Mass of glass fragments (grams)	*Probability of penetration (percent)*		
	1	50	99
	Impact velocity (ft/sec)		
0. 1	235	410	730
1. 0	140	245	430

cue for survival

OPERATION CUE

A.E.C. NEVADA TEST SITE

MAY 5, 1955

A report by the FEDERAL CIVIL DEFENSE ADMINISTRATION

EFFECTS OF NUCLEAR WEAPONS

BY HAROLD L. GOODWIN,
Director, Atomic Test Operations, FCDA

The time of travel of the shock wave is not generally understood by many persons. The concept of "duck and cover," which would still be of great value in case of attack without warning, is based on the comparatively large time interval between the burst and arrival of the shock wave at a given point.

92

BIOMEDICAL EFFECTS OF THERMAL RADIATION

BY DR. HERMAN ELWYN PEARSE, *Professor of Surgery at the University of Rochester. Consultant to several Government departments, notably the Atomic Energy Commission's Division of Biology and Medicine. Consultant to the Armed Forces Special Weapons Project*

After the Bikini test, I was asked to go to Japan as a consultant for the National Research Council to survey the casualties in Nagasaki and Hiroshima.

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Then we observed the healing of the wounds, and we found again that the wounds healed in the same manner as those that we had produced in the laboratory. There was some difference in these lesions from the ordinary burns of civil life, but I would predict, from what I learned from experiments, that the difference is on the good side. The burns look worse; they are often charred, but they may not penetrate as deeply, and the char acts as a dressing, nature's own dressing.

142

For example, if you have 2 layers, an undershirt and a shirt, you will get much less protection than if you have 4 layers; and if you get up to 6 layers, you have such great protection from thermal effects that you will be killed by some other thing. Under 6 layers we only got about 50 percent first degree burns at 107 calories.

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If we can just increase the protection a little bit, we may prevent thousands and thousands of burns.

... For example, to produce a 50-percent level of second-degree burns on bare skin required 4 calories. When we put 2 layers of cloth in contact, it only took 6 calories. But separate that cloth by 5 millimeters, about a fifth of an inch, and it increases the protective effect 5 times. The energy required to produce the same 50-percent probability of a second-degree burn is raised up to 30 calories. So if you wear loose clothing, you are better off than if your wear tight clothing.

144

STUDIES ON FLASH BURNS:

THE PROTECTION AFFORDED BY 2, 4 AND 6 LAYER FABRIC COMBINATIONS

George Mixter, Jr., M. D. and Herman E. Pearse, M. D.

THE UNIVERSITY OF ROCHESTER

ABSTRACT

Fabric interposed between a carbon arc source and the skin of Chester White pigs increased the amount of thermal energy required to cause 2+ burns. For the 2, 4 and 6 layers of fabric studied this increase was 3.6, 38 and over 104 cal/cm^2 respectively when the inner layer of fabric was in contact with the skin. Separation of the inner layer from the skin by 5 mm increased the protective effect of the 2 layer combination from 7.4 to 29 cal/cm^2, provided the outer layer was treated for fire retardation. If the outer layer was not so treated, sustained flaming occurred which in itself added to the thermal burn.

INTRODUCTION

In the past, work in this laboratory has been directed toward a study of flash burns in unshielded skin. It is well known from the atomic bombing in Japan that this type of burn was modified by clothing. A laboratory analysis of the protective effect of fabrics against flash burns was begun (5) by shielding the skin with a few representative fabrics and their combinations.

1. 2 Layers
   a. light green oxford
      knitted cotton underwear
   b. light green oxford (HPM)
      knitted cotton underwear
2. 4 Layers
   olive green sateen
   thin cotton oxford
   wool-nylon shirting
   knitted cotton underwear
3. 6 Layers
   olive green sateen
   thin cotton oxford
   mohair frieze
   rayon lining
   wool-nylon shirting
   knitted wool underwear

5. Morton, J. H., Kingsley, H. D., and Pearse, H. E., "Studies on Flash Burns: The Protective Effects of Certain Fabrics", Surgery, Gynecology and Obstetrics, 94, 497-501 (April 1952).

~~CONFIDENTIAL~~

UNCLASSIFIED

WT-770

This document consists of 64 pages

No. 196 of 295 copies, Series A

AD B951673

OPERATION UPSHOT-KNOTHOLE

Project 8.5

THERMAL RADIATION PROTECTION AFFORDED TEST ANIMALS BY FABRIC ASSEMBLIES

REPORT TO THE TEST DIRECTOR

by

J. Fred Oesterling and Staff

UNCLASSIFIED

REGRADED ....

BY AUTHORITY OF DA Form 1575, FCAG 274/24 2 Oct 6 Aug 63

BY B. W. [illegible] 23 Sep 64

July 1955

~~FORMERLY RESTRICTED DATA~~

Handle As Restricted D[redacted] in Foreign Dissemination S[redacted]on 144B, Atomic [redacted]

~~RESTRICTED DATA~~

[redacted] contains restricted data as defined in [redacted] Energy Act of 1954. Its transmittal or [redacted] of its contents in any manner to an una[redacted]ized [redacted]

Quartermaster Research and Development Laboratories
Army Medical Service Graduate School
Walter Reed Army Medical Center
University of Rochester Atomic Energy Project

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4.1.2 Factors Contributing to the Greater Degree of Thermal Protection in the Field.

There are several conditions encountered in the field, especially at the higher energy levels, but not duplicated in the laboratory (at least not up to the present time) that may account for the fact that like amounts of thermal energy did not produce comparable results in the laboratory and in the field. First, the thermal energy is delivered much more rapidly with the explosion of an atomic bomb than it is in the laboratory. Second, due to smoke obscuration the animals in the field actually received a smaller percentage of the total energy delivered than they did in the laboratory. Third, the blast wave following the explosion tended to extinguish flames and remove char, whereas no such wave was present in the laboratory tests. Fourth, where the heat reached the fabric layer next to the skin, uniform drape (or spacing) provided additional protection in the field.

(2) Motion pictures of clothed animals, exposed to 50.0 and 33.5 cal/cm^2 on Shots 9 and 10 respectively, showed heavy clouds

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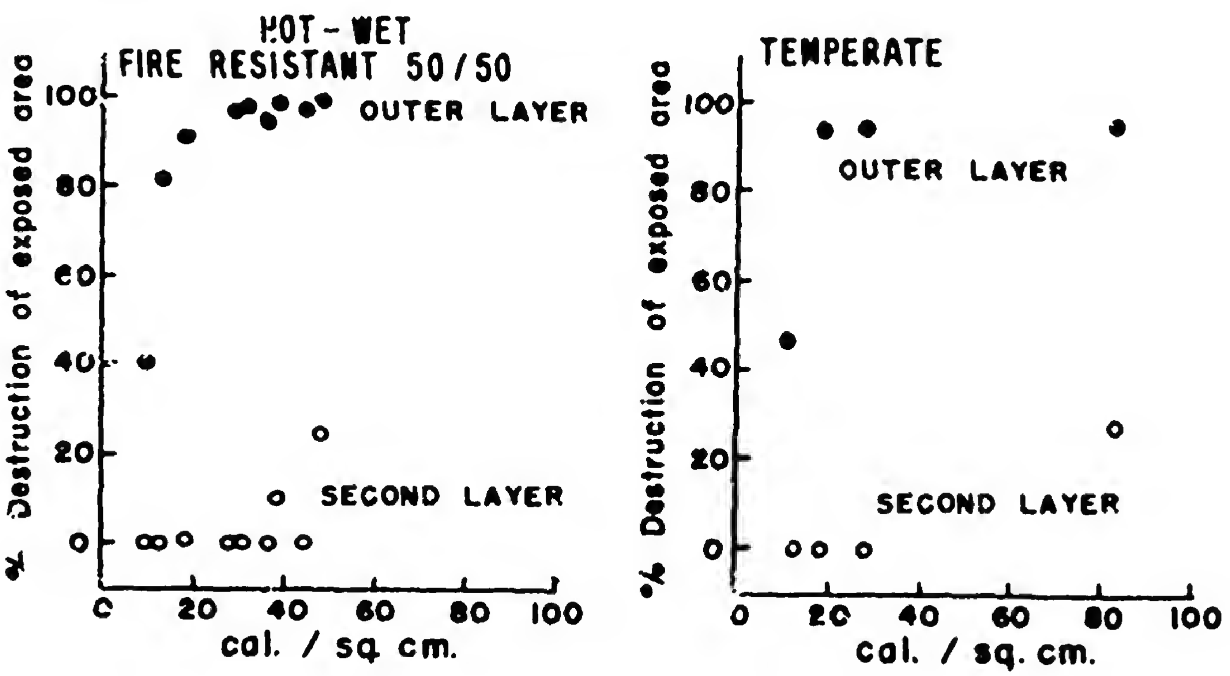
of black smoke enveloping the animals within 120 ms of the explosion.

(3) The blast wave following the explosion, which has not been duplicated in laboratory applications of thermal energy, has two possible protective effects. First, it can be expected to extinguish flames induced by the radiation in assemblies not treated for fire resistance, thus removing a source of high heat. Although the blast wave may not actually extinguish the flame in all cases,* it can be expected in general to have this effect. Second, the blast wave would tend to remove any char which, if allowed to remain, would act as a heat reservoir and increase the likelihood of a severe burn.

46

Fig. 3.5 Destruction of Outer and Second Layers of Pigs' Uniforms (Shots 9 and 10)



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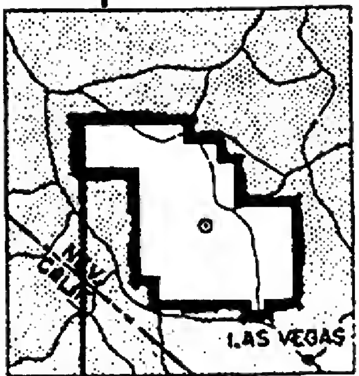
OPERATION PLUMBBOB



NEVADA TEST SITE
MAY-OCTOBER 1957

Project 8.2

PREDICTION of THERMAL PROTECTION of UNIFORMS, and THERMAL EFFECTS on a STANDARD-REFERENCE MATERIAL (U)

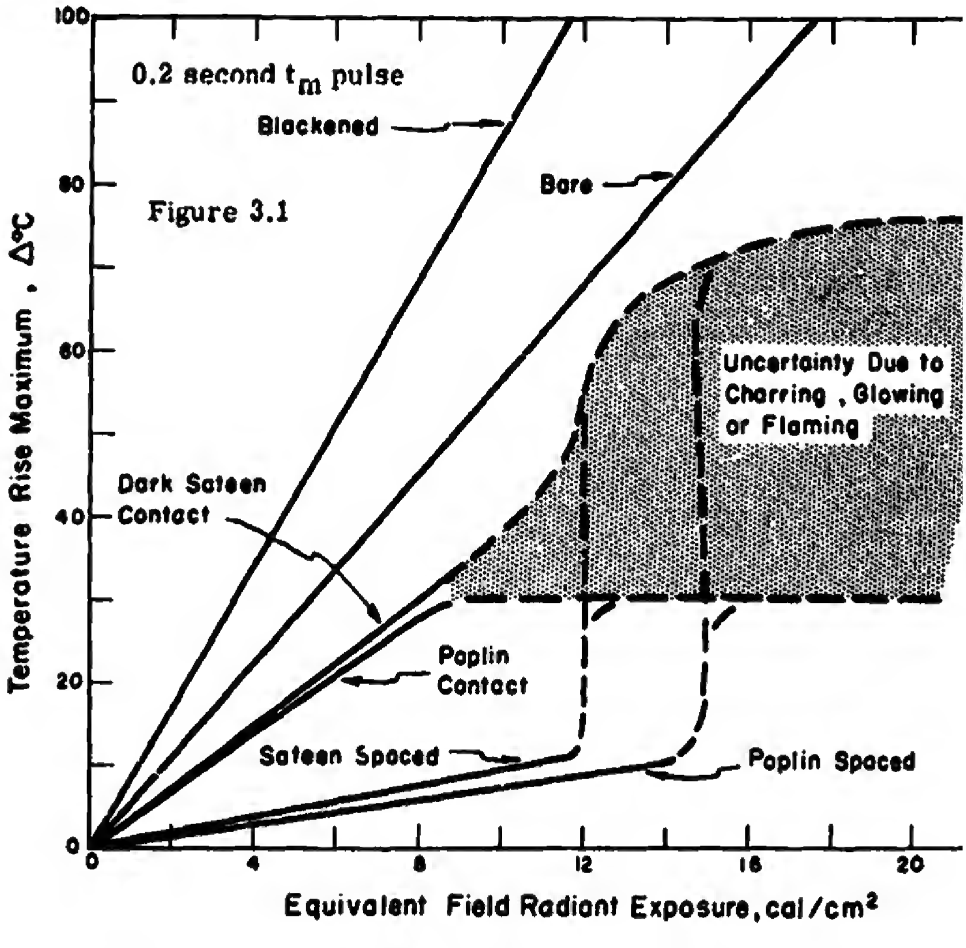
Issuance Date: May 2, 1960

HEADQUARTERS FIELD COMMAND
DEFENSE ATOMIC SUPPORT AGENCY
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

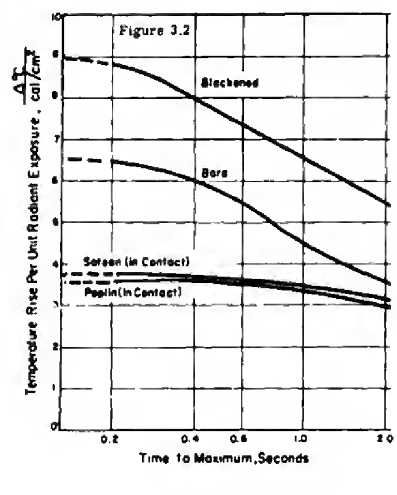
1.2.2 Comparison of Skin-Simulant Response and Burns to Pigs. The improved NML skin simulant, molded from silica-powder-filled urea formaldehyde, has the thermocouple embedded at a depth of 0.05 cm in order to give burn predictions based on maximum temperature attainment. The basic criterion is a rise of 25 C or more for a second-degree burn to human skin or for a 2+ mild burn to pig skin. This criterion is based on the assumption of (1) the equivalence of a minimal white burn on the rat skin (or a 2+ mild burn in pig skin) to a second-degree burn in human skin, (2) an initial skin temperature of 31 C, and (3) correspondence of the thermal properties of pig, rat, and human skin. The accuracy of such a burn prediction in terms of indicent radiant exposure is estimated to be ± 10 percent. A skin-simulant temperature rise of 20 C or greater is estimated to correspond to a first-degree human burn or a 1+ moderate pig skin burn, and a rise of 35 C is estimated for a third-degree human burn or a 3+ mild pig burn. The latter estimations, probably accurate to ± 20 percent, are based on pig-burn data obtained at the University of Rochester (Reference 6).

TABLE 2.1 RADIANT ABSORPTANCES OF SKIN SIMULANT AND STANDARD FABRICS

Specimen	Radiant Absorptance
Skin simulant, bare	0.72
Skin simulant, blackened	0.95
Poplin, Shade 116, 5-oz/yd²	0.63
Sateen, gray, 9-oz/yd²	0.91



NOTE: These pigs were strapped to tables and could not beat or roll out outer garment ignition unlike humans



Addendum No. 1

for

DNA 1240H-2, Part 2

HANDBOOK OF

UNDERWATER NUCLEAR EXPLOSIONS

21 January 1974

M. J. Dudash
DASIAC
General Electric Company-TEMPO
816 State Street
Santa Barbara, CA 93102

CHAPTER	TITLE	PAGE
	VOLUME 2 – PART 2	
18	SURFACE SHIP PERSONNEL CASUALTIES: EFFECTS OF UNDERWATER SHOCK ON PERSONNEL	18-1

19 August 1973 CHAPTER 18

18.7 THERMAL AND NUCLEAR RADIATION EFFECTS ON SURFACE SHIP PERSONNEL

18.7.1 Casualty and Risk Criteria

Table 18-2

CDC NUCLEAR AND THERMAL RADIATION CRITERIA

New Thermal Radiation Criteria

Risk Criteria for Burns Under Summer Uniforms to Warned, Exposed Personnel

	% Incidence	Mechanism	10KT cal/cm^2	100KT cal/cm^2	1000KT cal/cm^2
Negligible	2.5	1^{o} burn	3.1	4.2	5.8
Moderate	5	1^{o} burn	3.7	5.0	6.8
Emergency	5	2^{o} burn	6.3	8.8	12

	Casualties due to 2nd Degree Burns			
Time to Ineffectiveness	% Incidence	10KT cal/cm^2	100KT cal/cm^2	1000KT cal/cm^2
24. hr	50	38	53	73

Personnel Risk and Casualty Criteria for Nuclear Weapons Effects
ACN 4260, U. S. Army Combat Developments Command Institute of Nuclear Studies, August 1971

When water evaporates from the burned surface, cooling results and the body loses heat. The larger the burn wound, the more water loss and the more heat or energy loss.

How Can the Fluid and Heat Losses Be Diminished?

Think Plastic Wrap as Wound Dressing for Thermal Burns

ACEP (American College of Emergency Physicians) News
http://www.acep.org/content.aspx?id=40462

August 2008
By Patrice Wendling
Elsevier Global Medical News

CHICAGO - Ordinary household plastic wrap makes an excellent, biologically safe wound dressing for patients with thermal burns en route to the emergency department or burn unit.

The Burn Treatment Center at the University of Iowa Hospitals and Clinics, Iowa City, has advocated prehospital and first-aid use of ordinary plastic wrap or cling film on burn wounds for almost two decades with very positive results, Edwin Clopton, a paramedic and ED technician, explained during a poster session at the annual meeting of the American Burn Association.

“Virtually every ambulance in Iowa has a roll of plastic wrap in the back,” Mr. Clopton said in an interview. “We just wanted to get the word out about the success we've had using plastic wrap for burn wounds,” he said.

Dr. G. Patrick Kealey, newly appointed ABA president and director of emergency general surgery at the University of Iowa Hospital and Clinics, said in an interview that plastic wrap reduces pain, wound contamination, and fluid losses. Furthermore, it’s inexpensive, widely available, nontoxic, and transparent, which allows for wound monitoring without dressing removal.

“I can’t recall a single incident of its causing trouble for the patients,” Dr. Kealey said. “We started using it as an answer to the problem of how to create a field dressing that met those criteria. I suppose that the use of plastic wrap has spread from here out to the rest of our referral base.”

Although protocols vary between different localities, plastic wrap is typically used for partial- and full-thickness thermal burns, but not superficial or chemical burns. It is applied in a single layer directly to the wound surface without ointment or dressing under the plastic and then secured loosely with roller gauze, as needed.

Because plastic wrap is extruded at temperatures in excess of 150° C, it is sterile as manufactured and handled in such a way that there is minimal opportunity for contamination before it is unrolled for use, said Mr. Clopton of the emergency care unit at Mercy Hospital, Iowa City. However, it’s best to unwind and discard the outermost layer of plastic from the roll to expose a clean surface.

November 1963
Second printing May 1964

Unclassified Version

SURVEY OF THE THERMAL THREAT OF NUCLEAR WEAPONS

Prepared for:

OFFICE OF CIVIL DEFENSE
DEPARTMENT OF DEFENSE
WASHINGTON 25, D.C.

By: Jack C. Rogers and T. Miller

SRI Project No. IMU-4021

Approved:

Robert A. Harker

ROBERT A. HARKER, DIRECTOR
MANAGEMENT SCIENCES DIVISION

OCD REVIEW NOTICE

This report represents the authors' views, which in general are in harmony with the technical criteria of the Office of Civil Defense. However, a preliminary evaluation by OCD indicates the need for further evaluation of the fire threat of nuclear weapons and formulation of promising research and action programs.

NOTE: discrepancies are due to HUMIDITY differences.
ENCORE nuclear test (Nevada desert) humidity was ONLY 19%

Table B-VII

COMPARISON OF ESTIMATES FOR IGNITION ENERGY REQUIREMENTS
(10 mt)

Glasstone (1962) The Effects of Nuclear Weapons		Martin, et al. (1959) Naval Radiological Defense Laboratory		
Material	Cal/cm^2 for Ignition	Material	Cal/cm^2 for Ignition	Ratio of NRDL to ENW
Cotton auto seat upholstery, green, brown, white	16	Heavy cotton draperies, dark color	28	1.75
Wool pile chair upholstery, wine	35 (not sustained)	Wool pile chair upholstery, dark color	25	0.7
Newspaper, single sheet	6	Newspaper, medium printed	40	6.7
		Newspaper, dark areas	30	5.
Kraft paper carton, flat side exposed, used, brown	15	Corrugated Kraft board	40	2.6
Deciduous leaves	12	Walnut leaves	54	4.5
		Beech leaves	36	3.
Coarse grass	16	Harding grass	44	2.7
Ponderosa pine needles, brown	18	Pine needles	50	2.7

Sources: Martin, et al. (1959) and Glasstone (1962).

Martin, S. B., On Predicting the Ignition Susceptibility of Typical Kindling Fuels to Ignition by the Thermal Radiation from Nuclear Detonations, Tech. Report 367, U.S. Naval Radiological Defense Laboratory, San Francisco, Calif., April 1959. (U)

UCRL-TR-231593

LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

Thermal Radiation from Nuclear Detonations in Urban Environments

R. E. Marrs, W. C. Moss, B. Whitlock

June 7, 2007

Even without shadowing, the location of most of the urban population within buildings causes a substantial reduction in casualties compared to the unshielded estimates. Other investigators have estimated that the reduction in burn injuries may be greater than 90% due to shadowing and the indoor location of most of the population [6].

We have shown that common estimates of weapon effects that calculate a "radius" for thermal radiation are clearly misleading for surface bursts in urban environments. In many cases only a few unshadowed vertical surfaces, a small fraction of the area within a thermal damage radius, receive the expected heat flux.

6. L. Davisson and M. Dombroski, private communication; "Radiological and Nuclear Response and Recovery Workshop: Nuclear Weapon Effects in an Urban Environment 2007," M. Dombroski, B. Buddemeier, R. Wheeler, L. Davisson, T. Edmunds, L. Brandt, R. Allen, L. Klennert, and K. Law, UCRL-TR-XXXX (2007), in review.

HOME OFFICE
SCOTTISH HOME DEPARTMENT

MANUAL OF CIVIL DEFENCE

Volume I

PAMPHLET No. 1

NUCLEAR WEAPONS

LONDON
HER MAJESTY'S STATIONERY OFFICE
1956

The probable fire situation in a British city

35 Japanese houses are constructed of wood and once they were set on fire they continued to burn even when knocked over. In this country only about 10 per cent. of all the material in the average house is combustible, and under conditions of complete collapse, where air would be almost entirely excluded, it is doubtful whether a fire could continue on any vigorous scale.

40 It seems unlikely from the evidence available that an initial density of fires equivalent to one in every other building would be started by a nuclear explosion over a British city. Studies have shown that a much smaller proportion of buildings than this would be exposed to thermal radiation and even then it is not certain that continuing fires would develop. Curtains may catch fire, but it does not necessarily follow that they will set light to the room; in the last war it was found that only one incendiary bomb out of every six that hit buildings started a continuing fire.

From a 10 megaton bomb, with its longer lasting thermal radiation (see paragraph 21), it takes about 20 calories per square centimetre to start fires because so much of the heat (spread out over the longer emission) is wasted by conduction into the interior of the combustible material and by convection and re-radiation whilst the temperature of the surface is being raised to the ignition point. But the distance at which 20 calories per square centimetre can be produced is only 11 miles, so that the scaling factor for a 10 megaton airburst bomb is therefore 11 and not 22.

43 For a ground burst bomb, however, several other factors contribute to a further reduction in the fire range. Apart from an actual loss of heat by absorption into the ground and from the pronounced shielding effect of buildings, the debris from the crater tends to reduce the radiating temperature of the fireball and a greater proportion of the energy is consequently radiated in the infra red region of the spectrum —this proportion being more easily absorbed by the atmosphere.

44 An important point in relation to personal protection against the effects of hydrogen bomb explosions is that because the thermal radiation lasts so long there is more time for people who may be caught in the open, and who may be well beyond the range of serious danger from blast, to rush to cover and so escape some part of the exposure. For example, people in the open might receive second degree burns (blistering) on exposed skin at a range of 16 miles from a 10 megaton ground burst bomb (8×2—see paragraph 24). If, however, they could take cover in a few seconds they would escape this damage. Moreover, at this range the blast wave would not arrive for another minute and a half so that any effects due to the blast in the open (e.g. flying glass, etc.) could be completely avoided.

HANDBOOK

on

CAPABILITIES

of

ATOMIC WEAPONS

10.3 Damage Criteria

10.31 The tables presented in this section show various target items, their criteria for different degrees of damage and pertinent remarks. The items are listed in alphabetical order for each type of military operation. An attempt is made to give the source of the data by use of numbers to the right of the damage criteria. The key of this numbering system is indicated below:

a. Full-scale test data (including Hiroshima and Nagasaki . . (1)

b. Estimates made from scale experiments . . . . (2)

c. Theoretical analysis . . . . (3)

d. Consensus of qualified persons . . . . (4)

10.32 For those items not included in Table VIII, select the listed item most similar in those characteristics discussed previously as being the important factors in determining the extent of damage to be expected. Perhaps the most important item to be remembered when estimating effects on personnel is the amount of cover actually involved. This cover depends on several items; however, one factor is all important, namely, the degree of forewarning of an impending atomic attack. It is obvious that only a few seconds warning is necessary under most conditions in order to take fairly effective cover. The large number of casualties in Japan resulted for the most part from the lack of warning.

~~CONFIDENTIAL~~

DEPARTMENT OF THE ARMY TECHNICAL MANUAL — TM 23-200

DEPARTMENT OF THE NAVY — OPNAV INSTRUCTION 03400.1B

DEPARTMENT OF THE AIR FORCE — AFL 136-1

MARINE CORPS PUBLICATIONS — NAVMC 1104 REV

CAPABILITIES OF ATOMIC WEAPONS (U)

Prepared by
Armed Forces Special Weapons Project

DEPARTMENTS OF THE ARMY, THE NAVY AND THE AIR FORCE

REVISED EDITION NOVEMBER 1957

~~CONFIDENTIAL~~

Personnel in structures. A major cause of personnel casualties in cities is structural collapse and damage. The number of casualties in a given situation may be reasonably estimated if the structural damage is known. Table 6–1 shows estimates of casualty production in two types of buildings for several damage levels. Data from Section VII may be used to predict the ranges at which specified structural damage occurs. Demolition of a brick house is expected to result in approximately 25 percent mortality, with 20 percent serious injury and 10 percent light injury. On the order of 60 percent of the survivors must be extricated by rescue squads. Without rescue they may become fire or asphyxiation casualties, or in some cases be subjected to lethal doses of residual radiation. Reinforced concrete structures, though much more resistant to blast forces, produce almost 100 percent mortality on collapse. The figures of table 6–1 for brick homes are based on data from British World War II experience. It may be assumed that these predictions are reasonably reliable for those cases where the population is in a general state of expectancy of being subjected to bombing and that most personnel have selected the safest places in the buildings as a result of specific air raid warnings. For cases of no prewarning or preparation, the number of casualties is expected to be considerably higher.

6–2

Glass breakage extends to considerably greater ranges than almost any other structural damage, and may be expected to produce large numbers of casualties at ranges where personnel are relatively safe from other effects, particularly for an unwarned population.

Table 6–1. Estimated Casualty Production in Structures for Various Degrees of Structural Damage

	Killed outright	Serious injury (hospitalization)	Light injury (No hospitalization)
1–2 story brick homes (high explosive data):	*Percent*	*Percent*	*Percent*
Severe damage	25	20	10
Moderate damage	<5	10	5
Light damage	......	<5	<5

Note. These percentages do not include the casualties which may result from fires, asphyxiation, and other causes from failure to extricate trapped personnel. The numbers represent the estimated percentage of casualties expected at the maximum range where the specified structural damage occurs.

Personnel in a prone position are less likely to be struck by flying missiles than those who remain standing.

6–3

Table 6–2. Critical Radiant Exposures for Burns Under Clothing

(Expressed in cal/cm² incident on outer surface of cloth)

Clothing	Burn	1 KT	100 KT	10 MT
Summer Uniform	1°	8	11	14
(2 layers)	2°	20	25	35
Winter Uniform	1°	60	80	100
(4 layers)	2°	70	90	120

6–4

SECTION III
THERMAL RADIATION PHENOMENA

3.1 General

For a surface burst having the same yield as an air burst, the presence of the earth's surface results in a reduced thermal radiation emission and a cooler fireball when viewed from that surface. This is due primarily to heat transfer to the soil or water, the distortion of the fireball by the reflected shock wave, and the partial obscuration of the fireball by dirt and dust (or water) thrown up by the blast wave.

~~CONFIDENTIAL~~ 3–1

Measurements from the ground of the total thermal energy from surface bursts, although not as extensive as those for air bursts, indicate that the thermal yield is a little less than half that from equivalent air bursts. For a surface burst the thermal yield is assumed to be one-seventh of the total yield.

3–2 ~~CONFIDENTIAL~~

$$Q=\frac{3.16\times10^6\ W\ (\overline{T})}{D^2}\ \text{cal/sq cm (air burst).}$$

and

$$Q=\frac{1.35\times 10^6\ W\ (\overline{T})}{D^2}\ \text{cal/sq cm (surface burst).}$$

where Q=radiant exposure (cal/sq cm)
$\overline{T}$=atmospheric transmissivity
W=weapon yield (KT)
D=slant range (yds).

~~CONFIDENTIAL~~ 3–3

The differences between the air burst and surface burst curves are caused by the difference in apparent radiating temperatures (when viewed from the ground) and the difference in geometrical configuration of the two types of burst.

50 mile visibility and 5 gm/m³ water vapor.
10 mile visibility and 10 gm/m³ water vapor.

3.3 Radiant Exposure vs. Slant Range

a. Spectral Characteristics. At distances of operational interest, the spectral (wavelength) distribution of the incident thermal radiation, integrated with respect to time, resembles very closely the spectral distribution of sunlight. For each, slightly less than one-half of the radiation occurs in the visible region of the spectrum, approximately one-half occurs in the infrared region and a very small fraction (rarely greater than 10 percent) lies in the ultraviolet region of the spectrum. The color temperature of the sun and an air burst are both about 6,000° K. A surface burst, as viewed by a ground observer, contains a higher proportion of infrared radiation and a smaller proportion of visible radiation than the air burst, with almost no radiation in the ultraviolet region. The color temperature for a surface burst is about 3,000° K. A surface burst viewed from the air may exhibit a spectrum more nearly like an air burst.

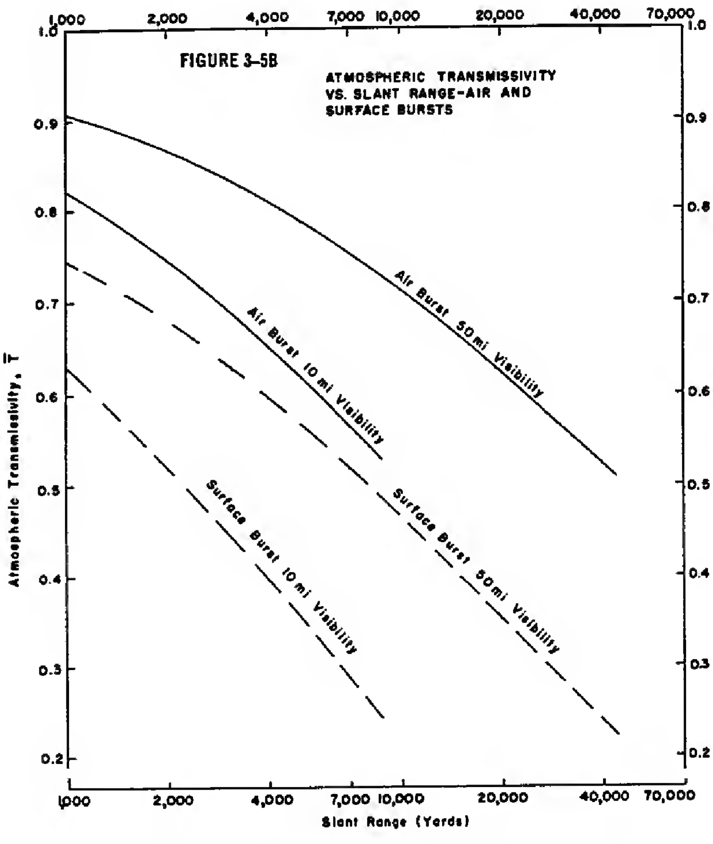


Table 12–2. Critical Radiant Exposure Values for Various Materials

Material	Damage	Critical radiant exposure Q_c, (cal/sq cm) 1 KT	100 KT	10 MT
Tent material:				
Canvas, white, 12 oz/yd^2, untreated	Destroyed	12	21	37
Canvas, OD, 12 oz/yd^2, flame-proofed	Destroyed	5	9	17
Packaging materials:				
Fibreboard, V2S, BT 350 psi, laminated	Flames during exposure	9	16	29
Fibreboard, V3S, BT 275 psi, laminated	Flames during exposure	7	13	23
Fibreboard, V3C, BT 350 psi, corrugated	Flames during exposure	6	11	19
Fibreboard, W5C, BT 200 psi, corrugated	Flames during exposure	5	10	18
Plywood, douglas fir (¼ in.)	Flames during exposure	9	16	20
Airship material, aluminized, N–113A100, 16 oz/yd^2	Aluminum surface discolored	20	35	61
	Aluminum surface destroyed	24	43	75
	Fabric destroyed	27	47	82
Airship material, aluminized, N–113A70, 19.4 oz/yd^2	Aluminum surface discolored	10	18	31
	Aluminum surface destroyed	15	27	44
	Fabric destroyed	20	35	61
Airship material, aluminized, N–128A170, 8 oz/yd^2	Delaminates	2	4	7
	Fabric destroyed	5	10	17
Doped fabrics (used on some aircraft control surfaces):				
Cellulose nitrate covered with 0.0015″ thick aluminum foil.	Sporadic flaming	60	80	140
Cellulose nitrate, aluminized	Persistent flaming	5	6	10
Plastics:				
Laminated methyl methacrylate	Surface melts	73	120	230
USAF window plastic (½ in.)	Bubbling	240	430	750
Vinylite (opaque), ⅛ in. thick	Dense smoking	3	4	6
	Flaming	20	20	25
Sand:				
Coral	Explosion*	15	27	47
Siliceous	Explosion*	11	19	35
Sandbags: Cotton canvas, dry, filled	Failure	10	18	32
Wood, white pine	0.1 mm depth char	10	18	32
White pine, given protective coating	0.1 mm depth char	40	71	126
Construction materials:				
Roll roofing, mineral surface	Surface melts	8	14	25
	Flaming during exposure	22	40	71
Roll roofing, smooth surface	Surface melts	4	7	12
	Flaming during exposure	9	16	29

*"Popcorning."

SECTION VII
DAMAGE TO STRUCTURES

7.1 General

Tunnels in solid rock are difficult to destroy by explosions of nuclear weapons. In this case, the shock wave is transmitted through the rock. When it reaches the tunnel the wave is reflected as a tensile wave, and there is a tendency for the rock to spall or become detached from the rock-tunnel interface. Use of tunnel linings materially reduces this spalling. Mass crushing of the rock and filling of the tunnel occurs closer to the burst point.

7.4 Field Fortifications

a. Air Blast. Air blast is the controlling damage-producing mechanism for destruction of field fortifications, including those reinforced, revetted or covered. Definitions of severe, moderate, and light damage levels to various types of field fortifications are given in table 7–4. These damage levels are based upon various degrees of collapse and structural failure except for unrevetted trenches and foxholes, which have damage levels based on degree of filling caused by collapse of the walls and by filling with dust and debris. Areas covered with loose material, such as sand and gravel, may provide sufficient dust and debris to completely fill a trench or foxhole, whereas areas with stable vegetation or areas of dry silty soil may not provide significant quantities of dust and debris to appreciably fill a trench or foxhole. Collapse of the walls of foxholes and trenches by air blast and air induced ground shock is usually not significant except at ranges less than those shown for severe damage in figure 7–22.

Table 7–4. Damage Criteria for Field Fortifications

Description	Severe
Unrevetted trenches and foxholes with or without light cover.	The trench or foxhole is at least 50 percent filled with earth.

FIGURES 7-20—7-22

The curves in figure 7–22 are based on results of tests run in a *consolidated dry sand and gravel soil*. Trenches and foxholes in damp soil with stable vegetation or dry silty soil will receive moderate and severe damage at ranges less than those shown in figure 7–22. The curves of figure 7–22 are for average rectangular foxholes with the longitudinal axis perpendicular to the direction of air blast propagation. Damage will be equal or less for other orientations.

Given: A 50 KT burst at an altitude of 1,000 feet.

Find: To what horizontal distance there is a 50 percent probability of severe damage to an unrevetted foxhole in a dry, consolidated sand and gravel soil.

Solution: 680 yards.

Approximately 20 psi peak overpressure

Table 7–3. Damage Criteria for Underground Structures

Structure	Damage	Damage distance	Remarks
Relatively small, heavy, well designed underground targets.	Severe	$1\frac{1}{4}R_a$	Collapse.
	Light	$2R_a$	Slight cracking, severance of brittle external connections.
Relatively long, flexible targets, such as buried pipelines, tanks, etc.	Severe	$1\frac{1}{2}R_a$	Deformation and rupture.
	Moderate	$2R_a$	Slight deformation and rupture.
	Light	$2\frac{1}{2}$ to $3R_a$	Failure of connections. (Use higher value for radial orientation of connections.)

Note. R_a=Apparent Crater Radius.

UNOBSTRUCTED (DESERT) TERRAIN
(NO ENERGY LOSS
FROM BLAST BY WORK)

FIGURE 7-10A

SEVERE DAMAGE TO REINFORCED CONCRETE FRAME OFFICE BUILDINGS

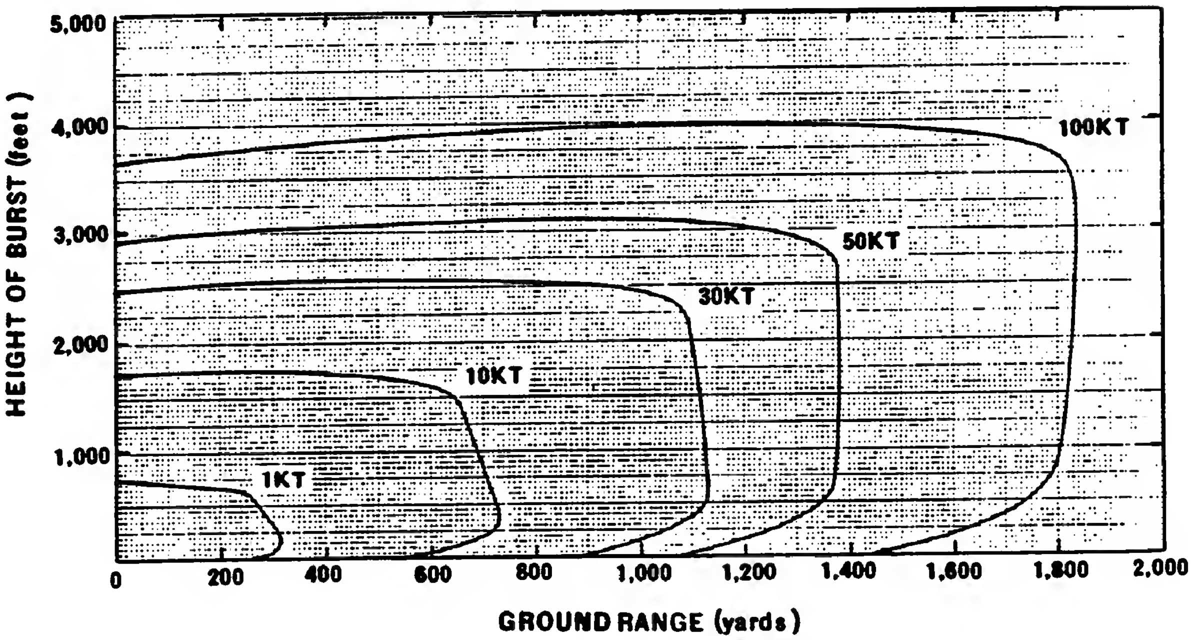


FIGURE 7-9A

SEVERE DAMAGE TO MULTISTORY STEEL FRAME OFFICE BUILDING

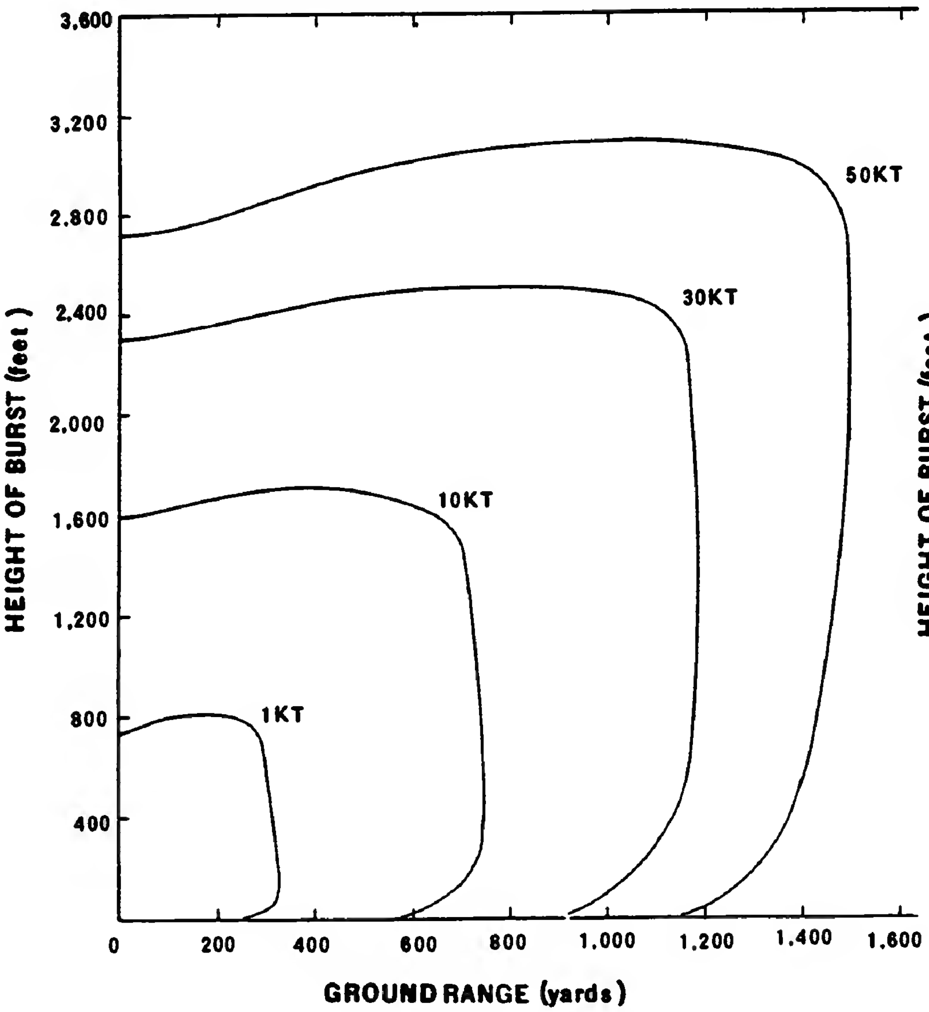
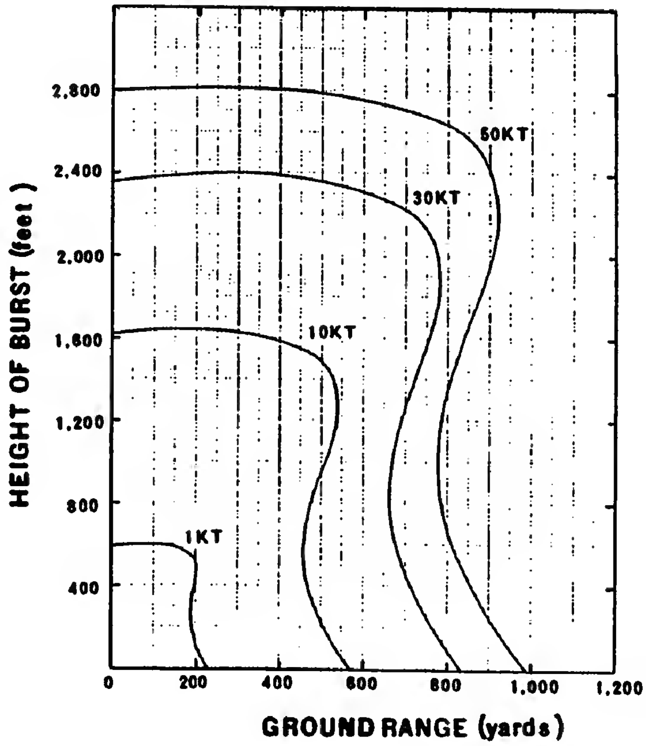


FIGURE 7-4A

SEVERE DAMAGE TO MONUMENTAL TYPE MULTISTORY WALL-BEARING BUILDINGS BY VARIOUS YIELDS



2.1c (1) FIGURE 2-6 GROWTH OF THE MACH STEM

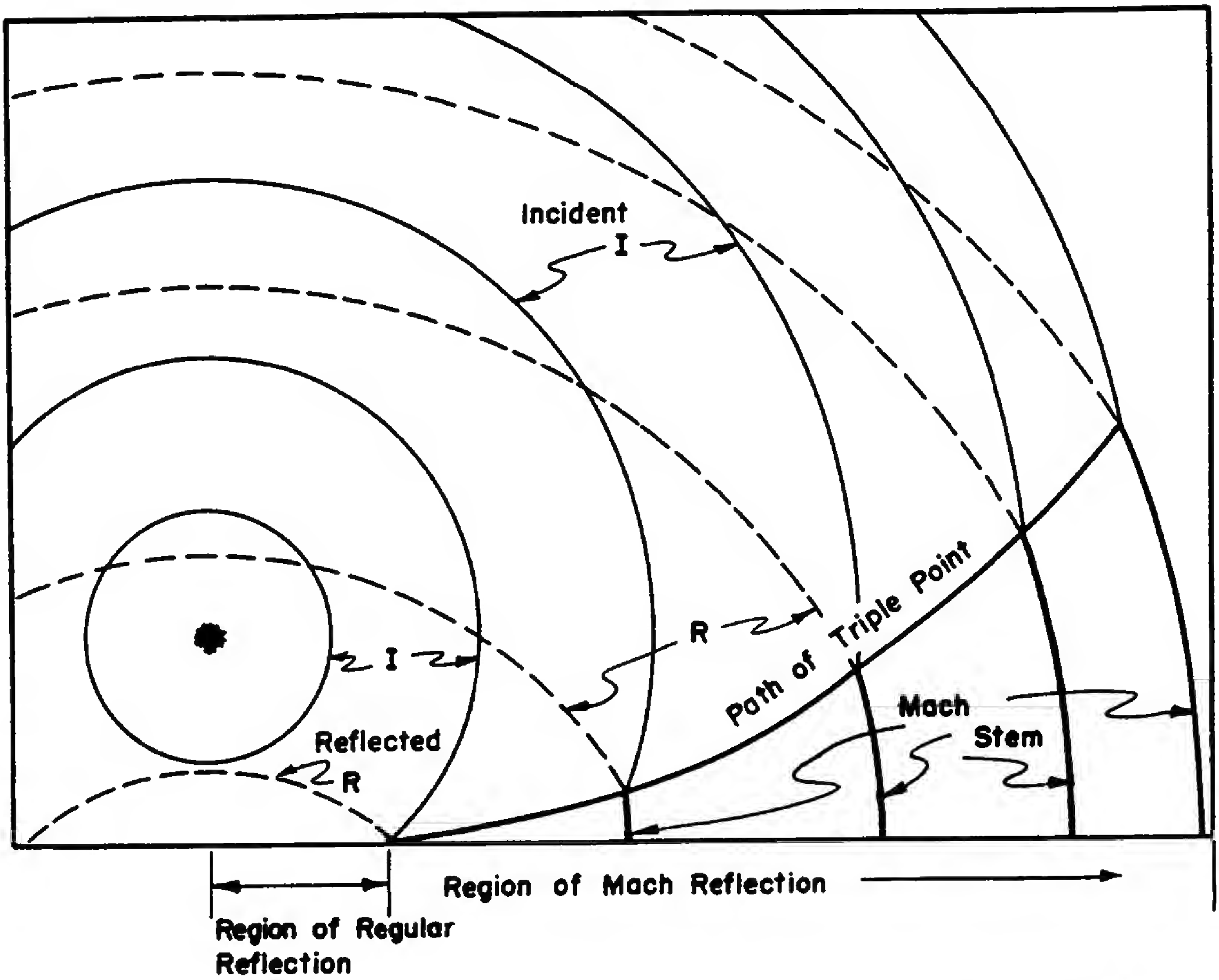


FIGURE 2-7 MACH STEM HEIGHT (1 KT) $\frac{H_1}{H_2}=\frac{h_1}{h_2}=\frac{d_1}{d_2}=\frac{W_1^{1/3}}{W_2^{1/3}}$

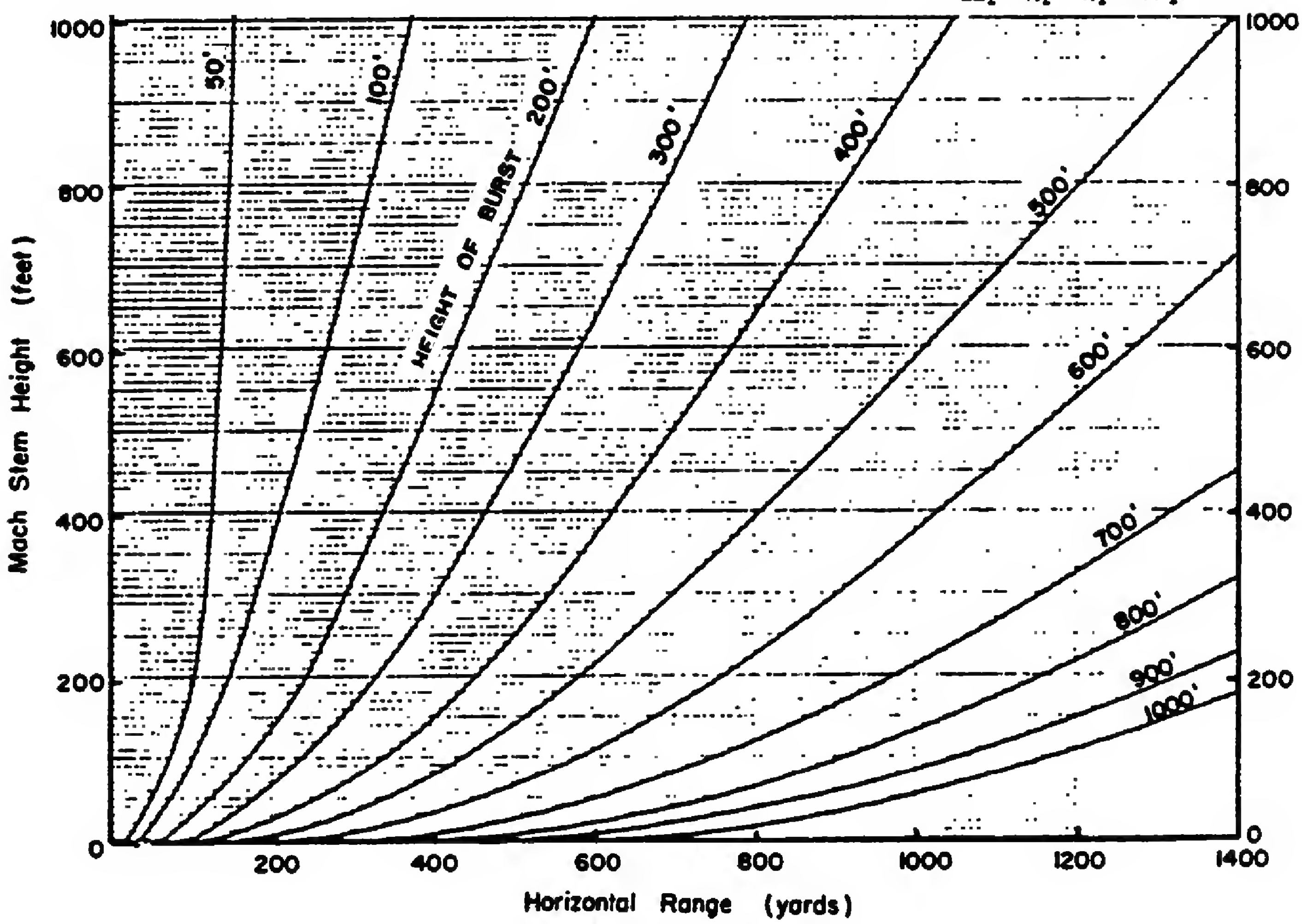
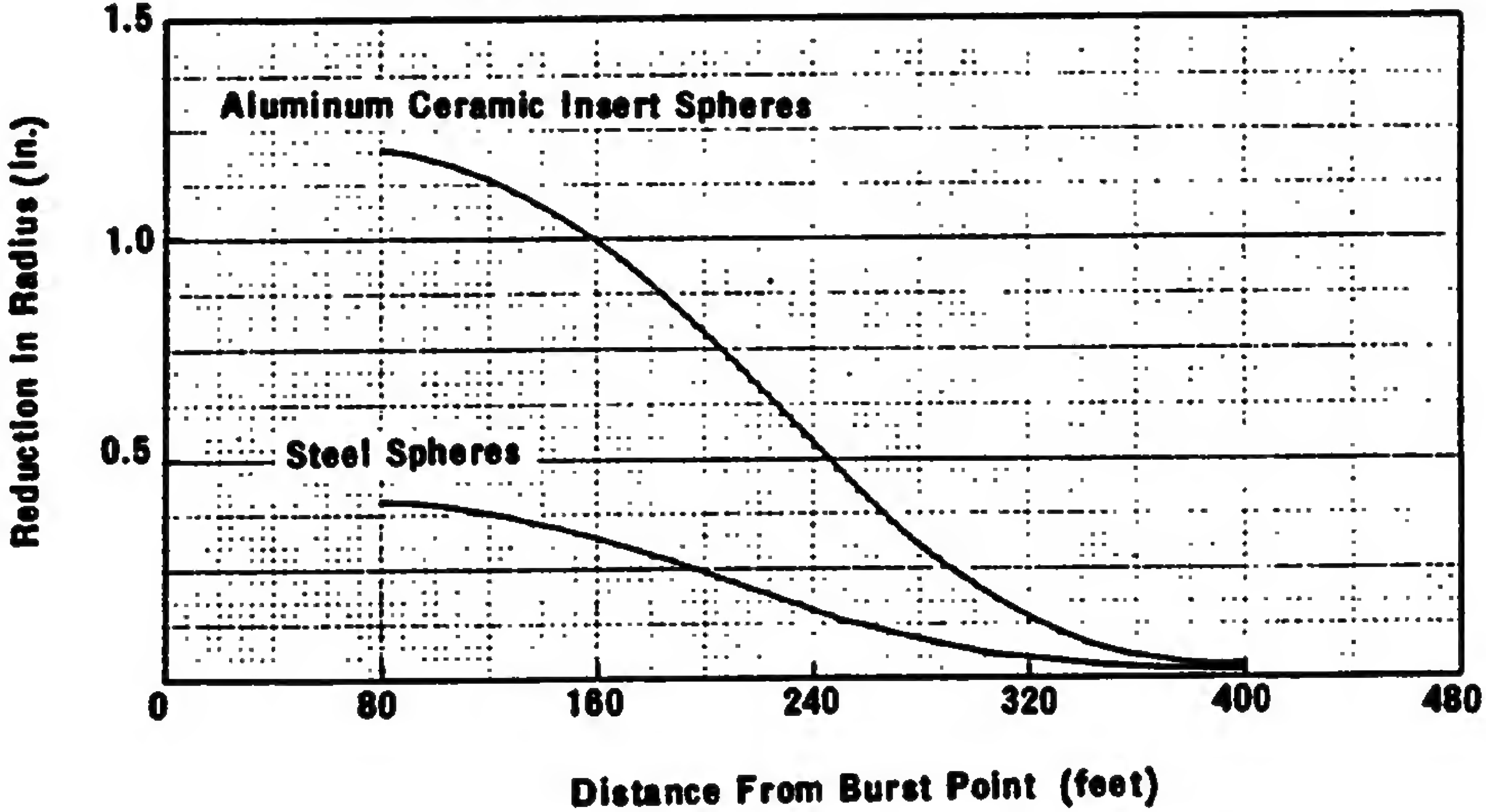
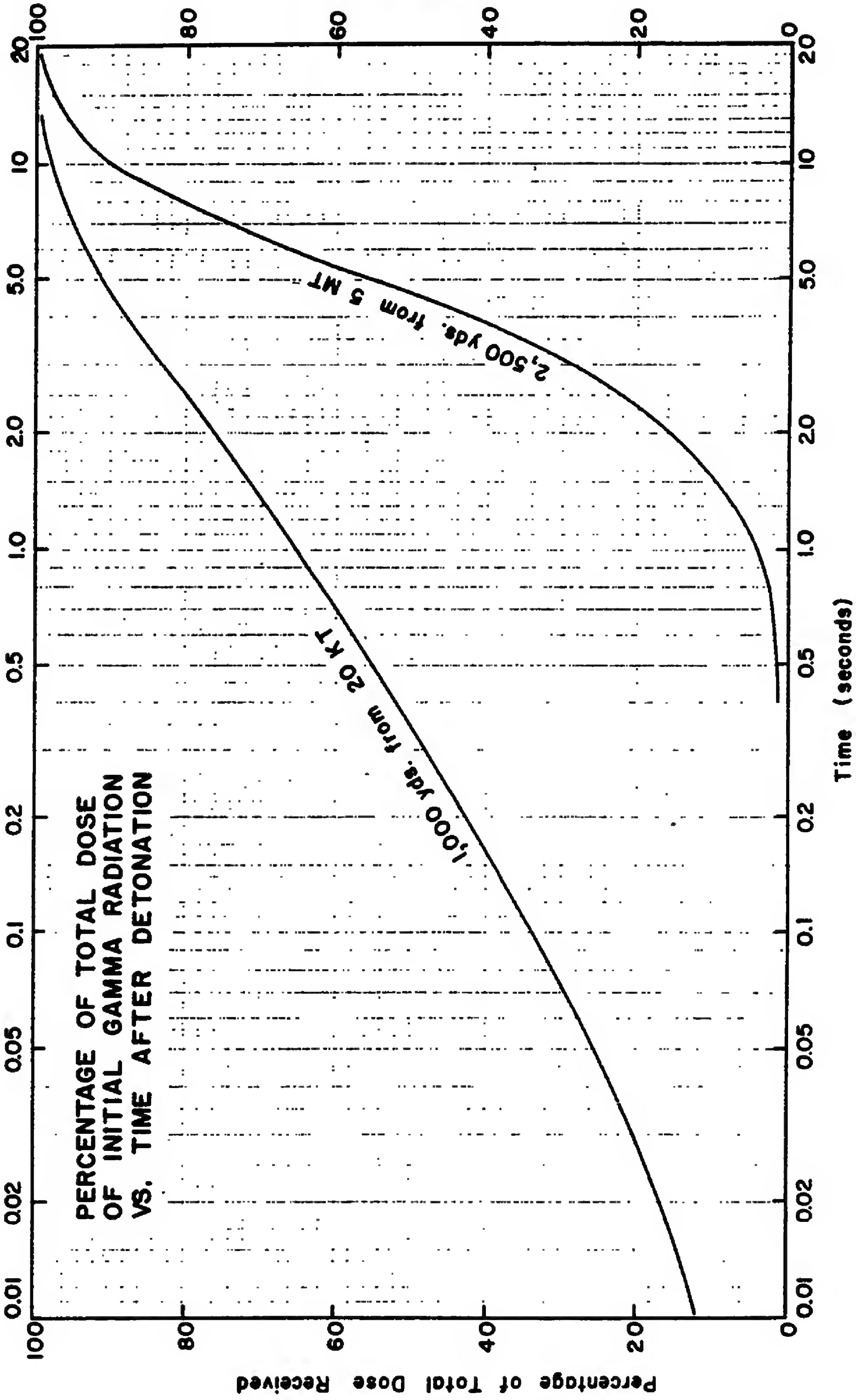


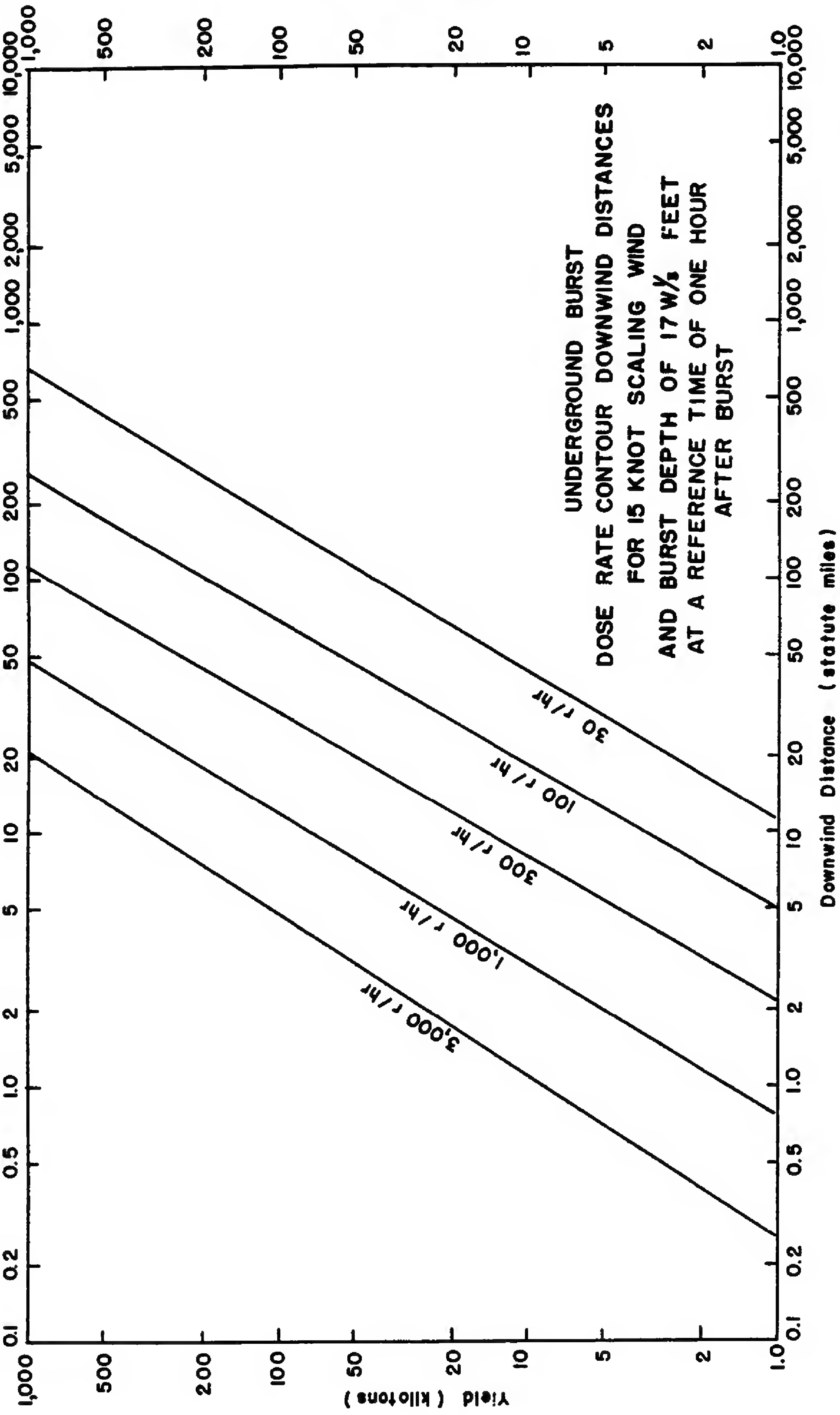
FIGURE 12-5B

TEAPOT-MET 1955 ablation of spheres inside fireball
10 inch diameter spheres

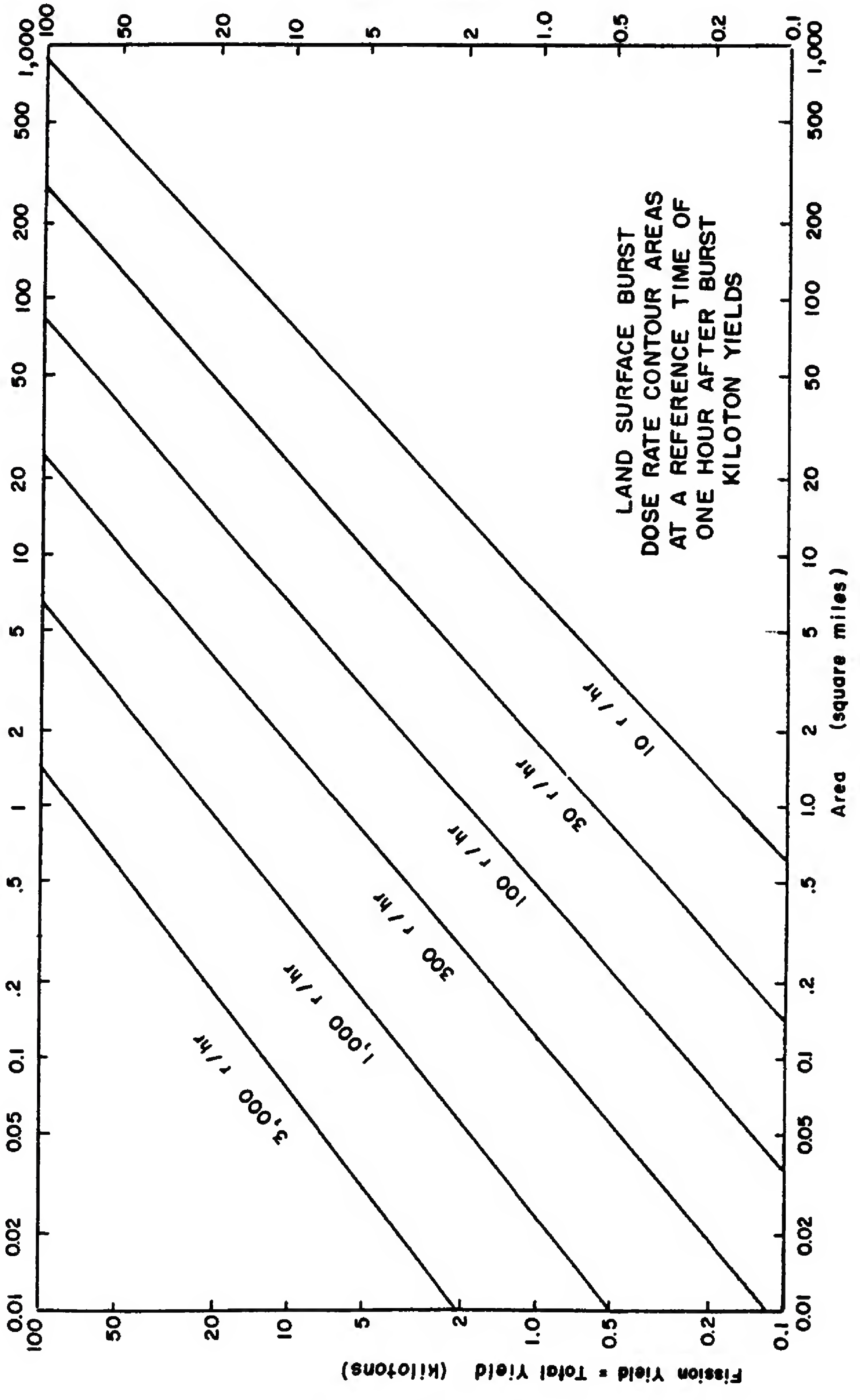
REDUCTION OF SPHERE RADIUS WITH DISTANCE FROM A 23 KT BURST
FOR ALUMINUM, STEEL, CERAMIC INSERT SPHERES



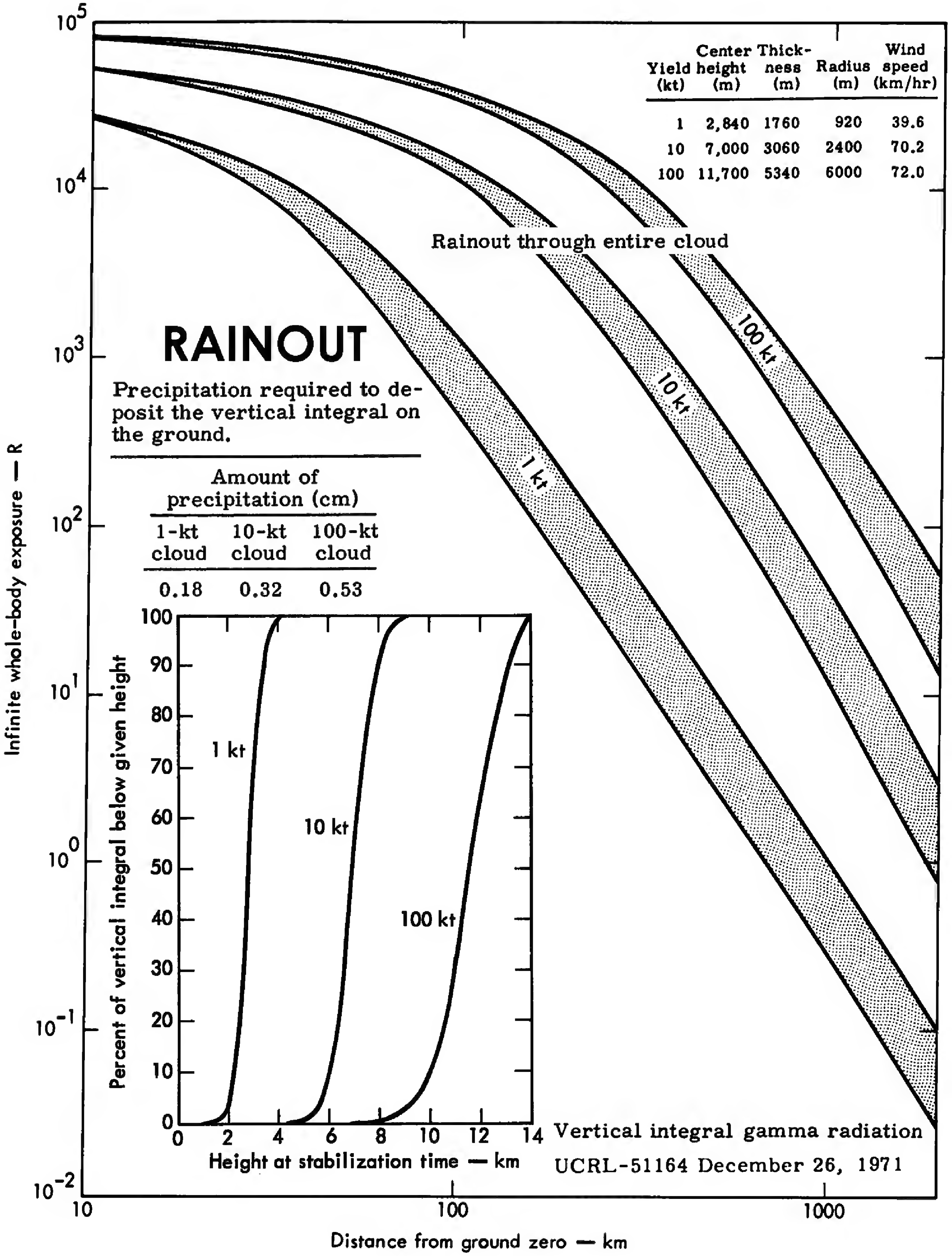

PERCENTAGE OF TOTAL DOSE
OF INITIAL GAMMA RADIATION
VS. TIME AFTER DETONATION
2,500 yds. from 5 MT
1,000 yds. from 20 KT
Time (seconds)
Percentage of Total Dose Received
0.01
0.02
0.05
0.1
0.2
0.5
1.0
2.0
5.0
10
20
0
20
40
60
80
100


UNDERGROUND BURST
DOSE RATE CONTOUR DOWNWIND DISTANCES
FOR 15 KNOT SCALING WIND
AND BURST DEPTH OF 17 W^1/3 FEET
AT A REFERENCE TIME OF ONE HOUR
AFTER BURST
30 r/hr
100 r/hr
300 r/hr
1,000 r/hr
3,000 r/hr
Downwind Distance (statute miles)
Yield (kilotons)
0.1
0.2
0.5
1.0
2
5
10
20
50
100
200
500
1,000
2,000
5,000
10,000
1.0
2
5
10
20
50
100
200
500
1,000

CONFIDENTIAL



CONFIDENTIAL



Vertical integral gamma radiation
UCRL-51164 December 26, 1971

FIRST CASUALTIES OF THE H-BOMB

by DWIGHT MARTIN

Five weeks out of Yaizu, her home port 120 miles southeast of Tokyo, the 99-ton tuna trawler *Fukuryu Maru* ("Fortunate Dragon") hove to at a position 166°30′ east longitude and 11°52′ north latitude. She dropped anchor and cast her nets at 5:30 a.m. on March 1. The *Fortunate Dragon*'s position, though her skipper and crew did not realize it, was 71 miles east-northeast of Bikini atoll and 14 miles outside the boundary of the restricted zone of the U.S. government's atomic testing area.

A calm sea was running and the weather was clear. Sunrise was at 6:09 a.m. and visibility was excellent. The *Fortunate Dragon*'s skipper, 24-year-old Tadaichi Tsutsui, was standing watch on the bridge, and eight crewmen were enthusiastically hauling in their first nets. After nearly three weeks of poor catches near Midway Island, the *Fortunate Dragon* had finally run into luck in more southern waters and her hold was already filled with 16,500 pounds of fat tuna. It was just a few seconds before 6:12 a.m.

"Then," said Crewman Sanjiro Masuda later, "we saw flashes of fire, as bright as the sun itself, rising to the sky. They rose about 10 degrees from the horizon and the sky around them glowed fiery red and yellow.

But Captain Tsutsui was getting more and more uneasy: "I thought, 'The bomb tests were being conducted over coral reefs. It could be pulverized coral ash, couldn't it?' " He thought some more about *shi no hai*, then ordered the crew to up anchor. The trawler steamed for home, 2,000 miles away.

"On the first night," said Radioman Aikichi Kuboyama, "we were unable to eat our supper. We tried drinking some sake (rice wine) to improve our appetites, but our appetites would not improve and the sake did not make us drunk. We were very depressed. Some of the crew grumbled '*pikadon*' but others said it couldn't be. I think someone said it was probably dust from some volcanic explosion."

AT HER DOCK the unfortunate *Fortunate Dragon*, still radioactive, floats untended by crewmen.

"We made port in Yaizu at 6 a.m. on March 14. We were now quite sick and frightened, and we went to see Dr. Toshisuke Oii at Kyoritsu hospital. He said we had severe burns and gave us some white ointment."

LIFE
Vol. 36, No. 13 March 29, 1954

WT-915 Castle-Bravo 15 megaton H-bomb test of 1 March 1954, which contaminated a Japanese tuna trawler and islanders

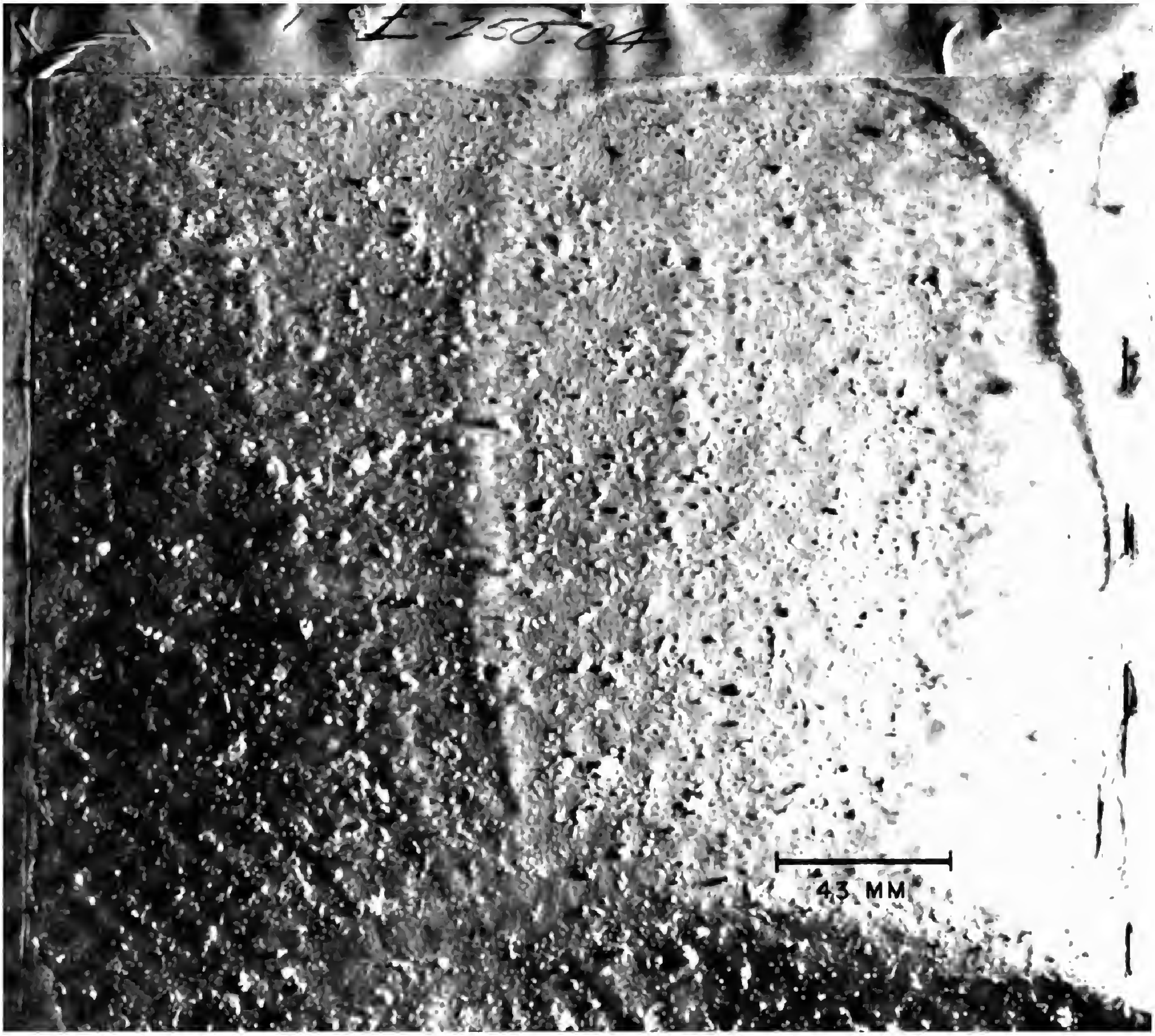


Fig. 5.10 Shot 1, Fallout Particulate, Station 250.04

This is a raft downwind in Bikini Lagoon, which received a land equivalent of 113 R/hr (1 hour reference gamma dose rate), according to Figures 2.2 and 6.1. Land equivalent dose rates were 7 times the raft dose rate in the lagoon.

According to Table 1 in Carl F. Miller's report USNRDL-466, 250.04 received 33.6 (mg/sq ft)/(R/hr at 1 hr) at 59.5 kft. Hence, 3.8 grams/sq ft.

SOME EFFECTS OF Ionizing Radiation ON HUMAN BEINGS

Report TID-5358

Case 26 at 45 days

Case 67 at 28 days and at 6 months after exposure
Beta burns occurred where fallout was retained

Case 72 at 28 days and at 6 months after exposure
Recovery from fallout beta burns to skin and hair

Less striking fallout described as "mist-like" was observed on Ailinginae and Rongerik. Fallout was not visible on Utirik, which was contaminated to only a mild degree. The severity of the skin manifestations was roughly proportional to the amount of fallout observed.

Group	Fallout Observed	Skin Lesions and Epilation
Rongelap	Heavy (snowlike)	Extensive.
Ailinginae	Moderate (mistlike)	Less extensive.
Rongerik	Moderate (mistlike)	Slight.
Utirik	None	No skin lesions or epilation.

a. *Shelter.* Those individuals who remained indoors or under the trees during the fallout period developed less severe lesions.

b. *Bathing.* Small children who went wading in the ocean developed fewer foot lesions.

[Clothing prevented fallout retention.]

FOR RELEASE AT 4:00 P.M. (E.S.T.)
TUESDAY, FEBRUARY 15, 1955

A REPORT

BY THE UNITED STATES ATOMIC ENERGY COMMISSION

ON THE EFFECTS OF HIGH-YIELD NUCLEAR EXPLOSIONS

FALLOUT PATTERN OF 1954 TEST IN THE PACIFIC

19. Data from this test permits estimates of casualties which would have been suffered within this contaminated area if it had been populated. These estimates assume: (1) that the people in the area would ignore even the most elementary precautions; (2) that they would not take shelter but would remain out of doors completely exposed for about 36 hours; and (3) that in consequence they would receive the maximum exposure. Therefore, it will be recognized that the estimates which follow are what might be termed extreme estimates since they assume the worst possible conditions.

PROTECTION AGAINST FALLOUT

26. In an area of heavy fallout the greatest radiological hazard is that of exposure to external radiation. Simple precautionary measures can greatly reduce the hazard to life. Exposure can be reduced by taking shelter and by utilizing simple decontamination measures until such times as persons can leave the area. Test data indicate that the radiation level, i.e., the rate of exposure, indoors on the first floor of an ordinary frame house in a fallout area would be about one-half the level out of doors. Even greater protection would be afforded by a brick or stone house. Taking shelter in the basement of an average residence would reduce the radiation level to about one-tenth that experienced out of doors.

29. If fallout particles come into contact with the skin, hair or clothing, prompt decontamination precautions such as have been outlined by the Federal Civil Defense Administration will greatly reduce the danger. These include such simple measures as thorough bathing of exposed parts of the body and a change of clothing.

30. If persons in a heavy fallout area heeded warning or notification of an attack and evacuated the area or availed themselves of adequate protective measures, the percentage of fatalities would be greatly reduced even in the zone of heaviest fallout.

AD696959

DASA 2019-2

Proceedings:

SECOND INTERDISCIPLINARY CONFERENCE ON SELECTED EFFECTS OF A GENERAL WAR

VOLUME II

This Conference was sponsored by the Defense Atomic Support Agency (Contract DASA 01-67-C-0024, NWER Subtask DB003) through the auspices of the New York Academy of Sciences Interdisciplinary Communications Program. It was held at Princeton, New Jersey, during 4-7 October 1967.

DASIAC Special Report 95
July 1969

SESSION II — Wright H. Langham — 45

LANGHAM: Fallout was predicted for the Trinity test in 1945 by the bomb phenologists, Hershfeider and McGee. Stafford Warren mounted evacuation teams and monitoring teams to cover the potential fallout area. We didn't have to evacuate anybody; we almost did. The arbitrary limit chosen for evacuation was an infinite life-time dose of 50 r. One family approached this limit, and there was much debate as to whether we should evacuate them or not. They weren't evacuated.

SESSION II — Theodore B. Taylor — 51

TAYLOR: I would like to interject something that you challenged, Staff. You said a moment ago, you can't hear it. Apropos of the Dog Shot, fallout was clearly audible. There were little beads of steel from the tower that condensed, and one heard this constant tinkle, tinkle of steel from the tower hitting the aluminum roofs and then rolling down the gutters and piling up in little piles on the ground.

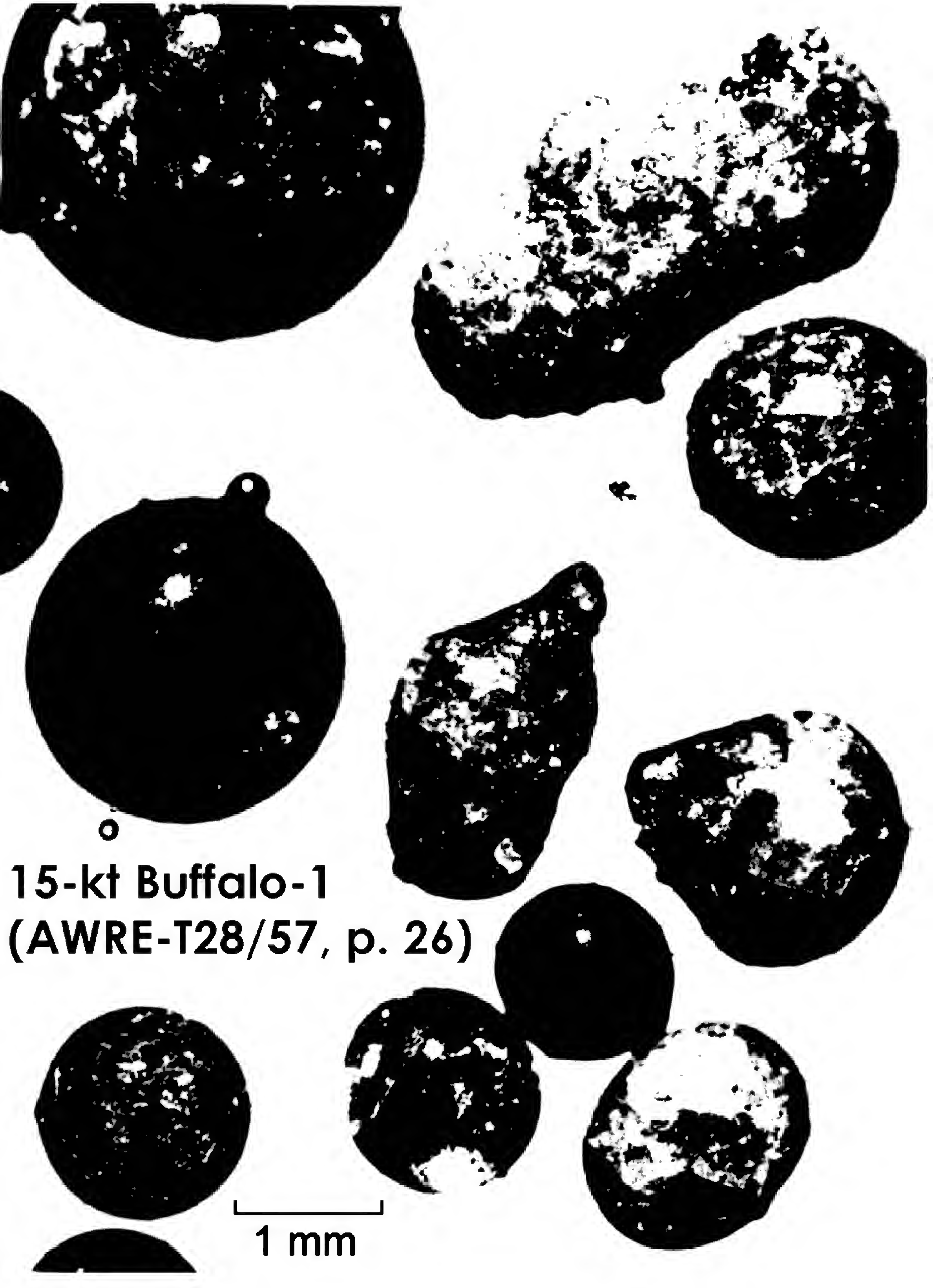
76 — Lin Root — DASA 2019-2

ROOT: Mutual Security Agreement—after Korea. It was terribly important that Japan become a responsible member of the organization. The Yoshida cabinet was entirely favorable to the U.S. and it looked as if there would not be too much opposition. Then the fishermen arrived. Demonstrations flared up everywhere. You had the trade unions, three million strong, protesting. The cabinet tried to counteract the anti-American feeling but a tidal wave of anger inundated the country. It was just diminishing when Koboyama died. This was portrayed as a radiation death.

FREMONT-SMITH: This is the fisherman that had the transfusion and the hepatitis?

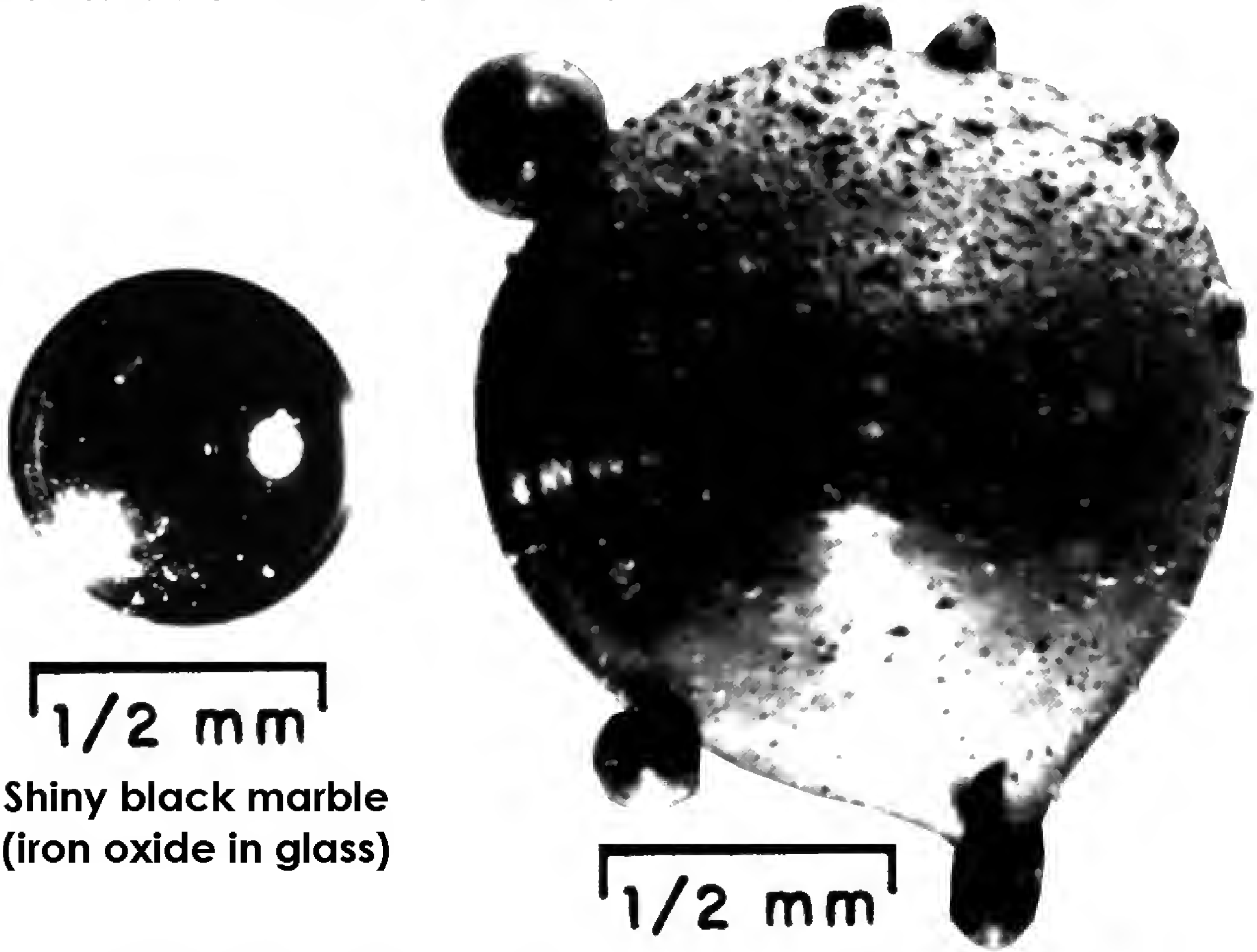
ROOT: Yes. Japanese doctors give very small blood transfusions, and Koboyama needed a great many.

Group	Composition	Fallout observed	Estimated gamma dose (rads)	Extent of skin lesions
Rongelap	64 Marshallese	Heavy (snowlike)	175	Extensive
Ailingnae	18 Marshallese	Moderate (mistlike)	69	Less extensive
Rongerik	28 Americans	Moderate (mistlike)	78	Slight
Utirik	157 Marshallese	None	14	No skin lesions or epilation



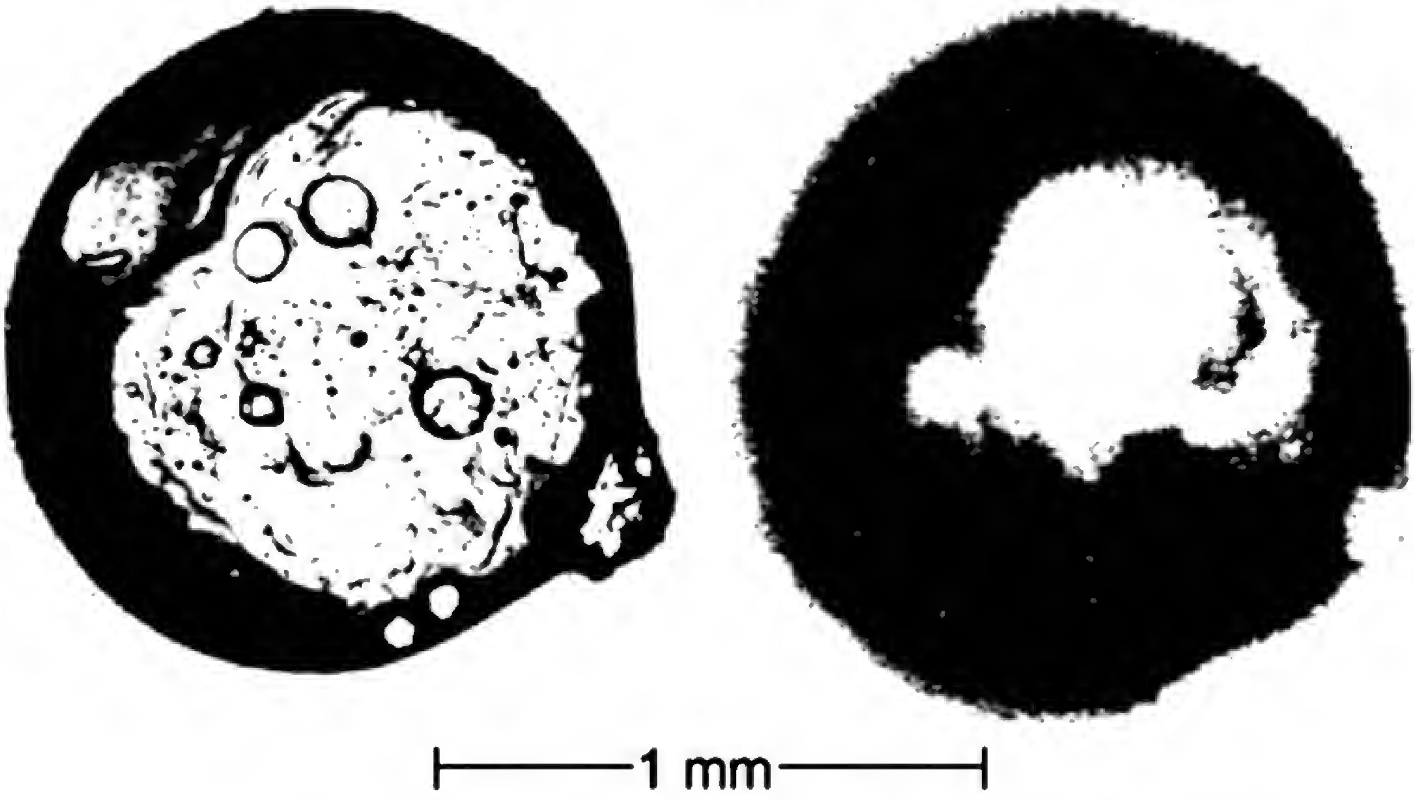
15-kt Buffalo-1
(AWRE-T28/57, p. 26)

TWO FALLOUT PARTICLES FROM A TOWER SHOT AT THE NEVADA TEST SITE. THE PARTICLE ON THE LEFT IS A PERFECT SPHERE WITH A HIGHLY GLOSSY SURFACE; THE ONE ON THE RIGHT HAS MANY PARTIALLY-ASSIMILATED SMALLER SPHERES ATTACHED TO ITS SURFACE. BOTH PARTICLES ARE BLACK AND MAGNETIC AND HAVE A SUPERFICIAL METALLIC APPEARANCE.



Shiny black marble (iron oxide in glass)

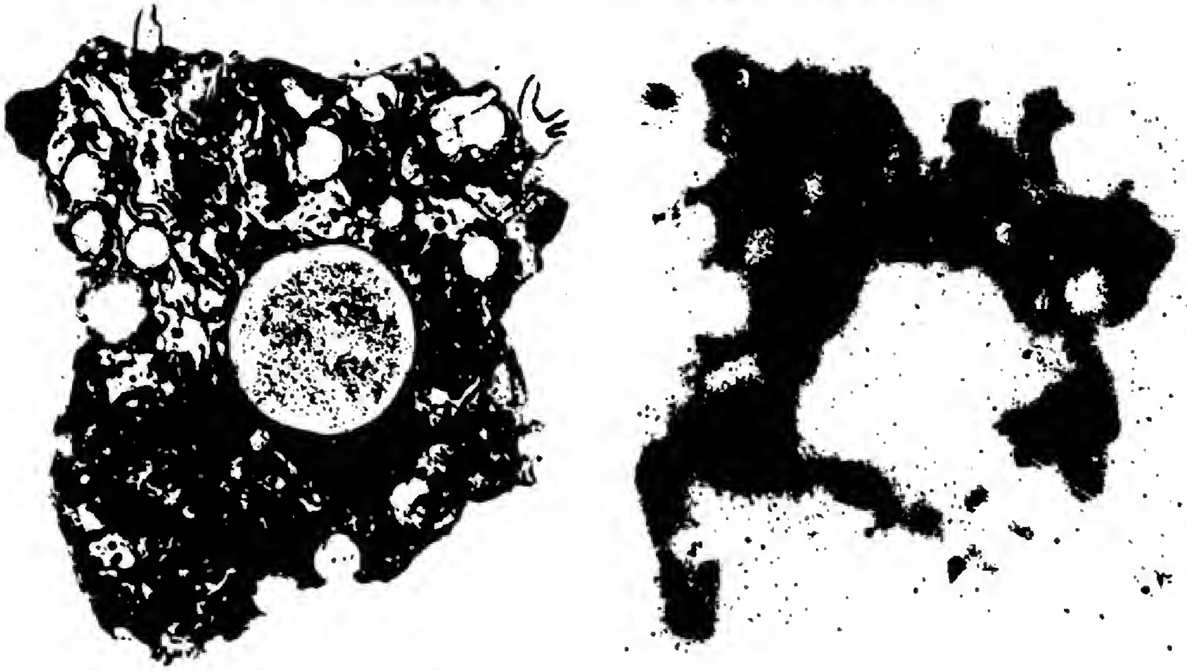
THIN SECTION AND RADIOGRAPH OF A FALLOUT PARTICLE FROM A MODERATE-YIELD TOWER SHOT AT THE NEVADA TEST SITE. THIS PARTICLE IS COMPOSED OF A TRANSPARENT GLASS CORE WITH A DARKLY COLORED IRON OXIDE GLASS OUTER ZONE. MOST OF THE RADIOACTIVITY IS CONCENTRATED IN THE OUTER ZONE



C.E. Adams. The Nature of Individual Radioactive Particles. IV. Fallout Particles From A.B.D. of Operation UPSHOT-KNOTHOLE. U.S. Naval Radiological Defense Laboratory Report, USNRDL-440, February 24, 1954

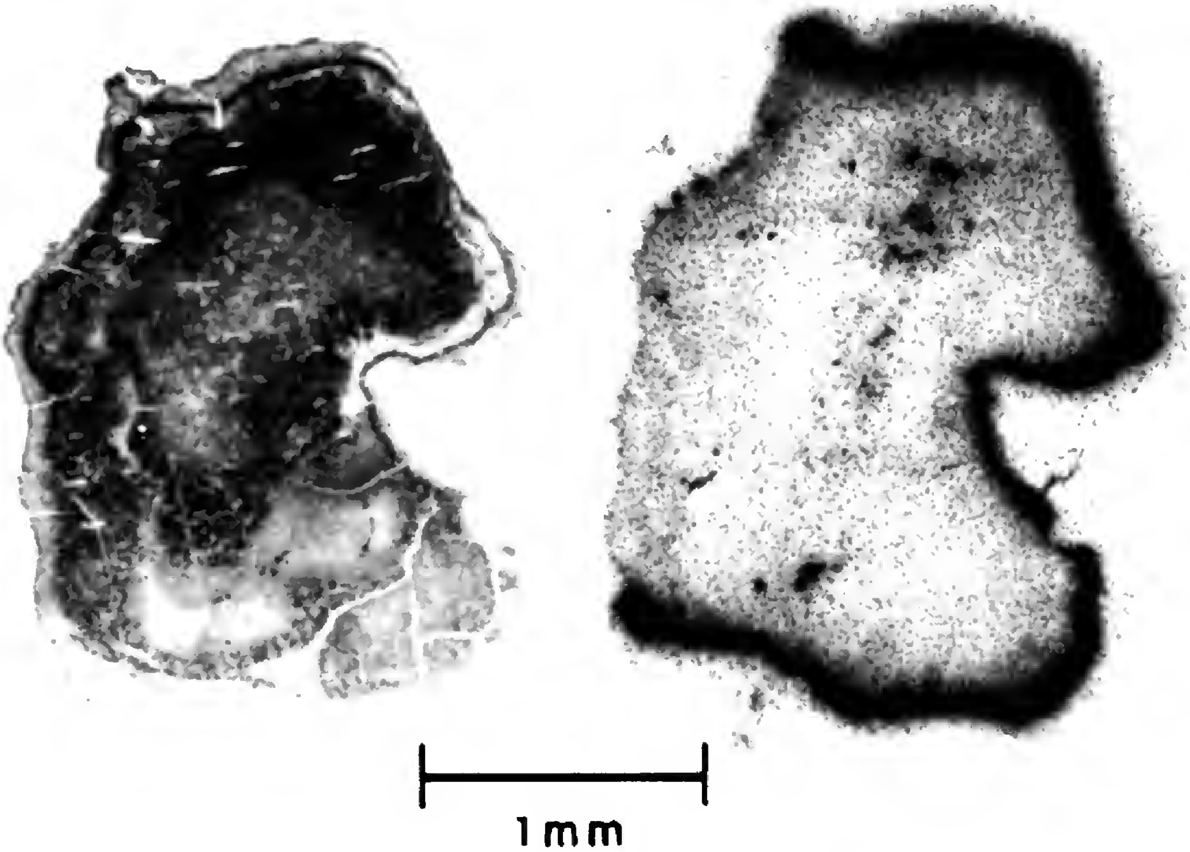
THIN SECTION AND RADIOGRAPH OF A FALLOUT PARTICLE FROM A SMALL-YIELD SURFACE SHOT AT THE NEVADA TEST SITE. THE PARTICLE IS A TRANSPARENT YELLOW-BROWN GLASS WITH MANY INCLUSIONS OF GAS BUBBLES AND UNMELTED MINERAL GRAINS. THE RADIOACTIVITY IS DISTRIBUTED IRREGULARLY THROUGHOUT THE GLASS PHASE OF THE PARTICLE

1.2 KT JANGLE-SUGAR NEVADA SURFACE BURST

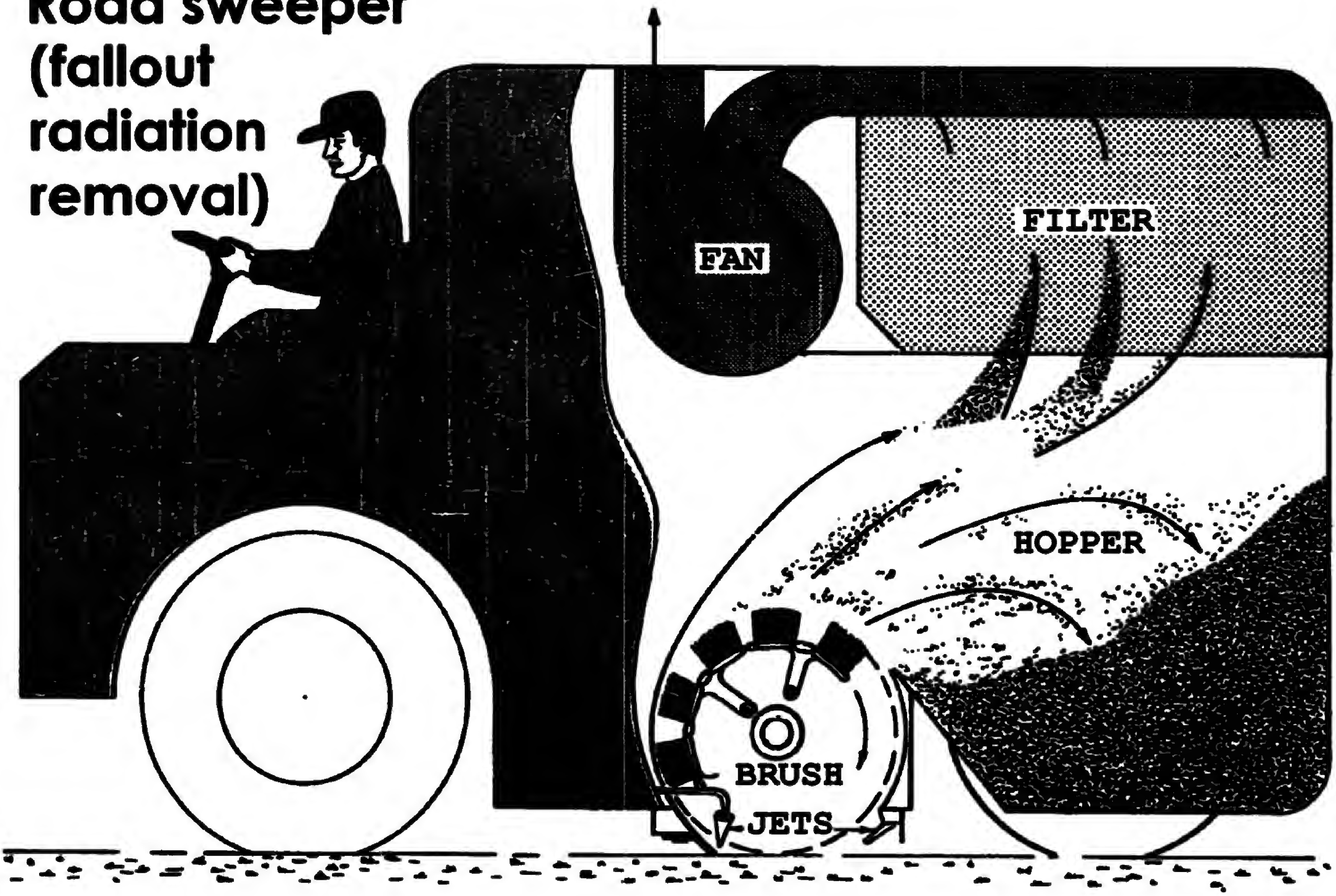


C.E. Adams, et al. The Nature of Individual Radioactive Particles. I. Surface and Underground A.B.D. Particles From Operation JANGLE. U.S. Naval Radiological Defense Laboratory Report, USNRDL-374, November 28, 1952

THIN SECTION AND RADIOGRAPH OF AN ANGULAR FALLOUT PARTICLE FROM A LARGE-YIELD SURFACE SHOT AT THE ENIWETOK PROVING GROUNDS. THIS PARTICLE IS COMPOSED ALMOST ENTIRELY OF CALCIUM HYDROXIDE WITH A THIN OUTER LAYER OF CALCIUM CARBONATE. THE RADIOACTIVITY HAS COLLECTED ON THE SURFACE AND HAS DIFFUSED A SHORT DISTANCE INTO THE PARTICLE



Road sweeper (fallout radiation removal)



USNRDL-TR-1049
28 July 1966

AD 641 480

REMOVAL OF SIMULATED FALLOUT FROM ASPHALT STREETS BY FIREHOSING TECHNIQUES

by

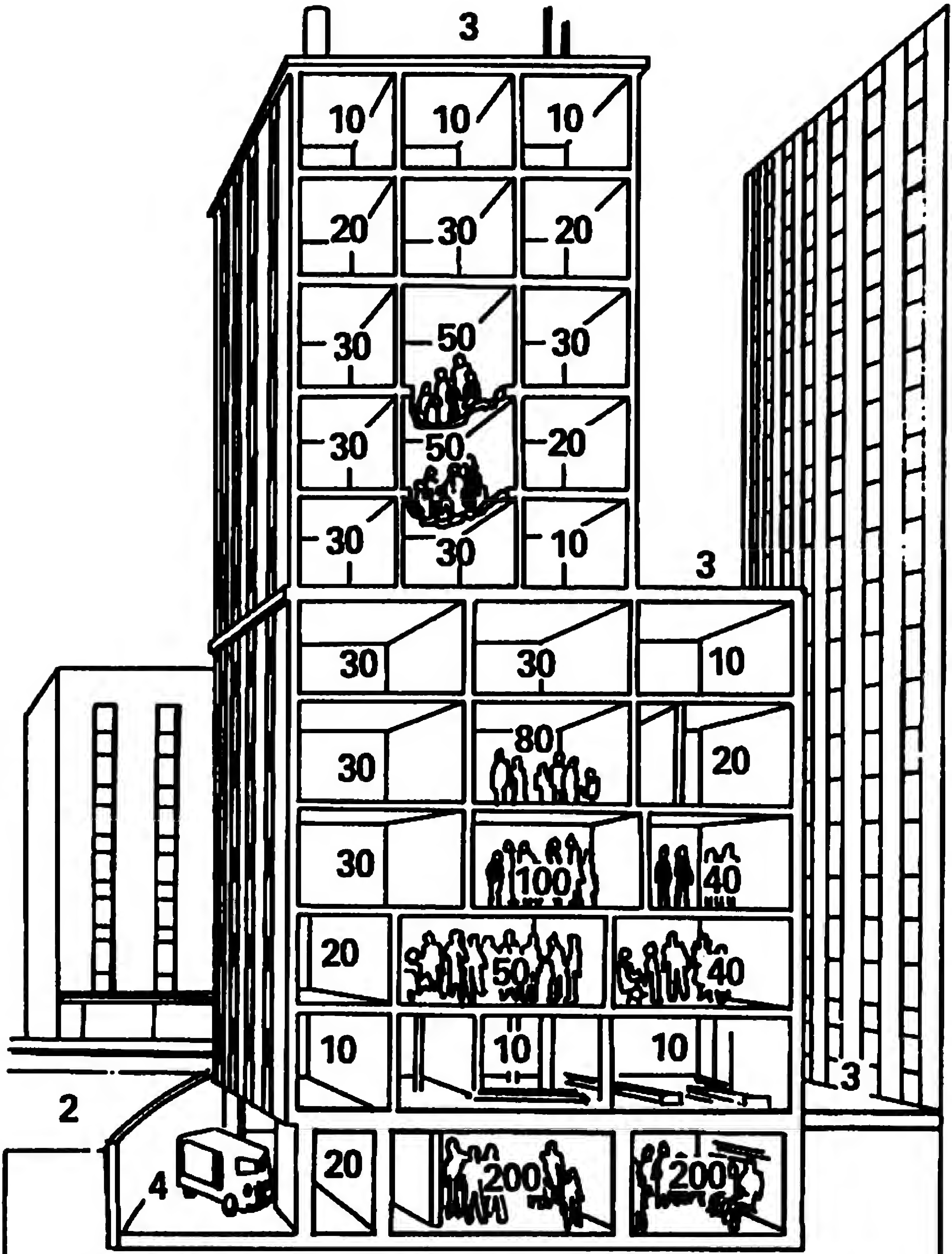
L.L.Wiltshire
W.L.Owen

In general, removal effectiveness improves with increased particle size range and increased mass loading. For the expenditure of an effort of 4 nozzle-minutes (12 man-minutes) per 10^3 ft^2, results ranged as follows:

Particle Size Range (μ)	Nominal Mass Loading (g/ft^2)	Removal Effectiveness (Residual Fraction)
44 - 88	4.0	0.16
	24.0	0.07
350 - 700	4.0	0.005
	24.0	0.003

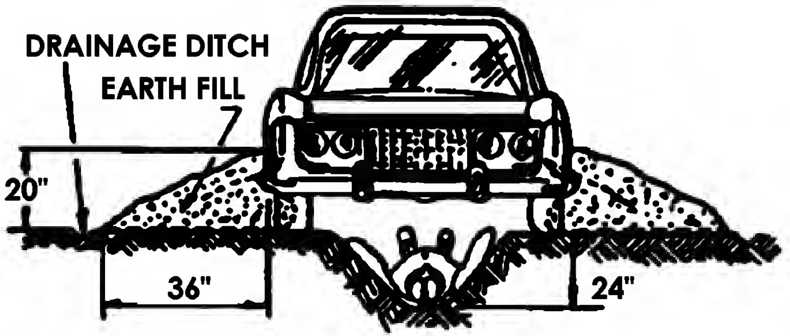
U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY

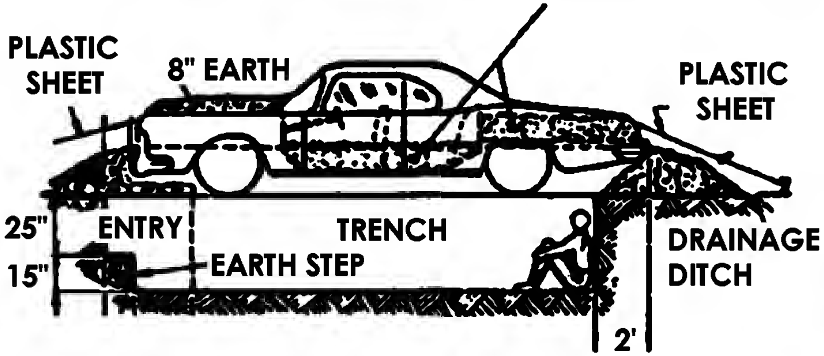
SAN FRANCISCO · CALIFORNIA 94135



Radiation protection factors in modern city buildings
DCPA Attack Environment Manual, ch. 6, panel 18

CAR-OVER-TRENCH FALLOUT SHELTER (EXPEDIENT SHELTER HANDBOOK)





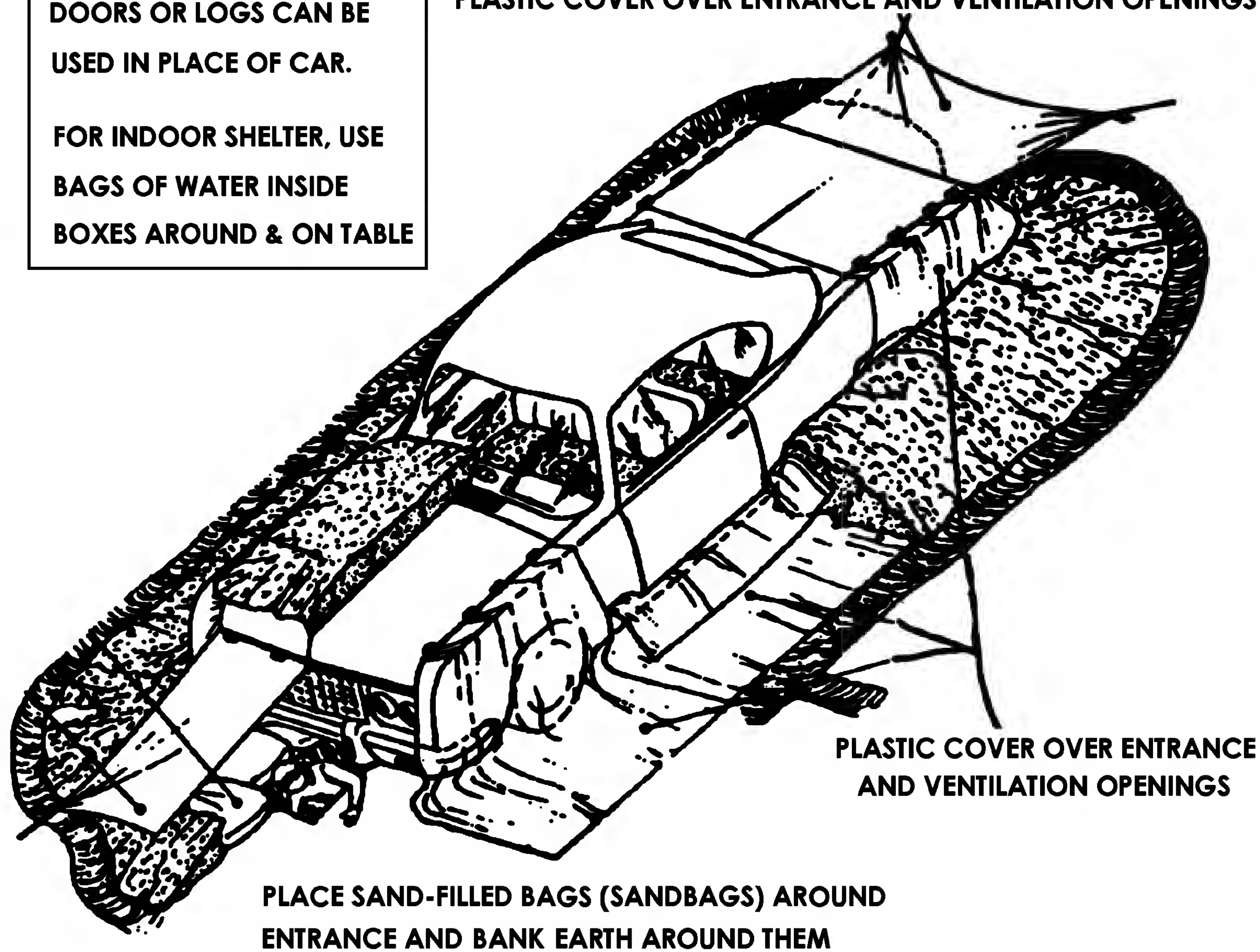
BANK EXCAVATED EARTH 20 INCHES HIGH AROUND CAR

PLACE 8" OF EARTH ON CAR HOOD

DIG SHALLOW DRAINAGE DITCH AROUND FILL

DOORS OR LOGS CAN BE USED IN PLACE OF CAR.

FOR INDOOR SHELTER, USE BAGS OF WATER INSIDE BOXES AROUND & ON TABLE




TRINITY GROUND ZERO:
8000 R/hr at 1 hour
1.4 R/hr at
57 days
11 Sept. 1945

TECHNICAL ANALYSIS REPORT - AFSWP NO. 507

RADIOACTIVE FALL-OUT HAZARDS FROM SURFACE BURSTS OF VERY HIGH YIELD NUCLEAR WEAPONS

by

D. C. Borg
L. D. Gates
T. A. Gibson, Jr.
R. W. Paine, Jr.

MAY 1954

HEADQUARTERS, ARMED FORCES SPECIAL WEAPONS PROJECT
WASHINGTON 13, D. C.

e. Passive defense measures, intelligently applied, can drastically reduce the lethally hazardous areas. A course of action involving the seeking of optimum shelter, followed by evacuation of the contaminated area after a week or ten days, appears to offer the best chance of survival. At the distant downwind areas, as much as 5 to 10 hours after detonation time may be available to take shelter before fall-out commences.

f. Universal use of a simply constructed deep underground shelter, a subway tunnel, or the sub-basement of a large building could eliminate the lethal hazard due to external radiation from fall-out completely, if followed by evacuation from the area when ambient radiation intensities have decayed to levels which will permit this to be done safely.

Table II

Total Isodose Contour: 500r from Fall-out to H+50 Hours

Yield (MT)	15	1	10	60
Downwind extent (mi)	180	52	152	340
Area (mi^2)	5400	470	3880	17,900

SANDIA REPORT
SAND2009-3299
Unlimited Release
Printed May 2009

Analysis of Sheltering and Evacuation Strategies for an Urban Nuclear Detonation Scenario

Larry D. Brandt, Ann S. Yoshimura

Executive Summary

A nuclear detonation in an urban area can result in large downwind areas contaminated with radioactive fallout deposition. Early efforts by local responders must define the nature and extent of these areas, and advise the affected population on strategies that will minimize their exposure to radiation. These strategies will involve some combination of sheltering and evacuation actions. Options for shelter-evacuate plans have been analyzed for a 10 kt scenario in Los Angeles.

Results from the analyses documented in this report point to the following conclusions:

- When high quality shelter (protection factor ~10 or greater) is available, shelter-in-place for at least 24 hours is generally preferred over evacuation.
- Early shelter-in-place followed by informed evacuation (where the best evacuation route is employed) can dramatically reduce harmful radiation exposure in cases where high quality shelter is not immediately available.
- Evacuation is of life-saving benefit primarily in those hazardous fallout regions where shelter quality is low and external fallout dose rates are high. These conditions may apply to only small regions within the affected urban region.
- External transit from a low quality shelter to a much higher quality shelter can significantly reduce radiation dose received if the move is done soon after the detonation and if the transit times are short.

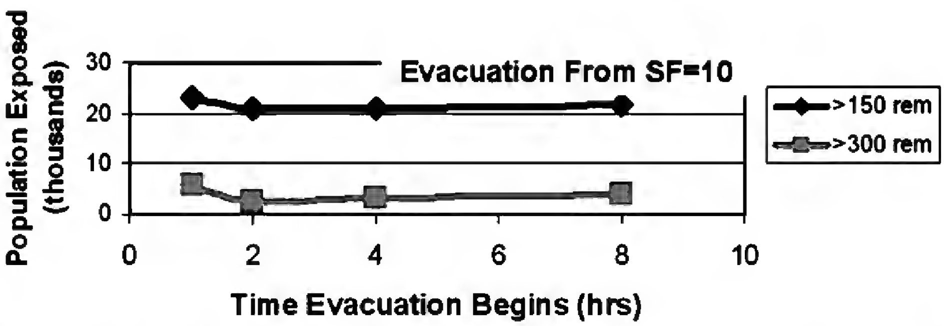


Figure 12. Departure time sensitivities for informed evacuations from shelters with SF=4

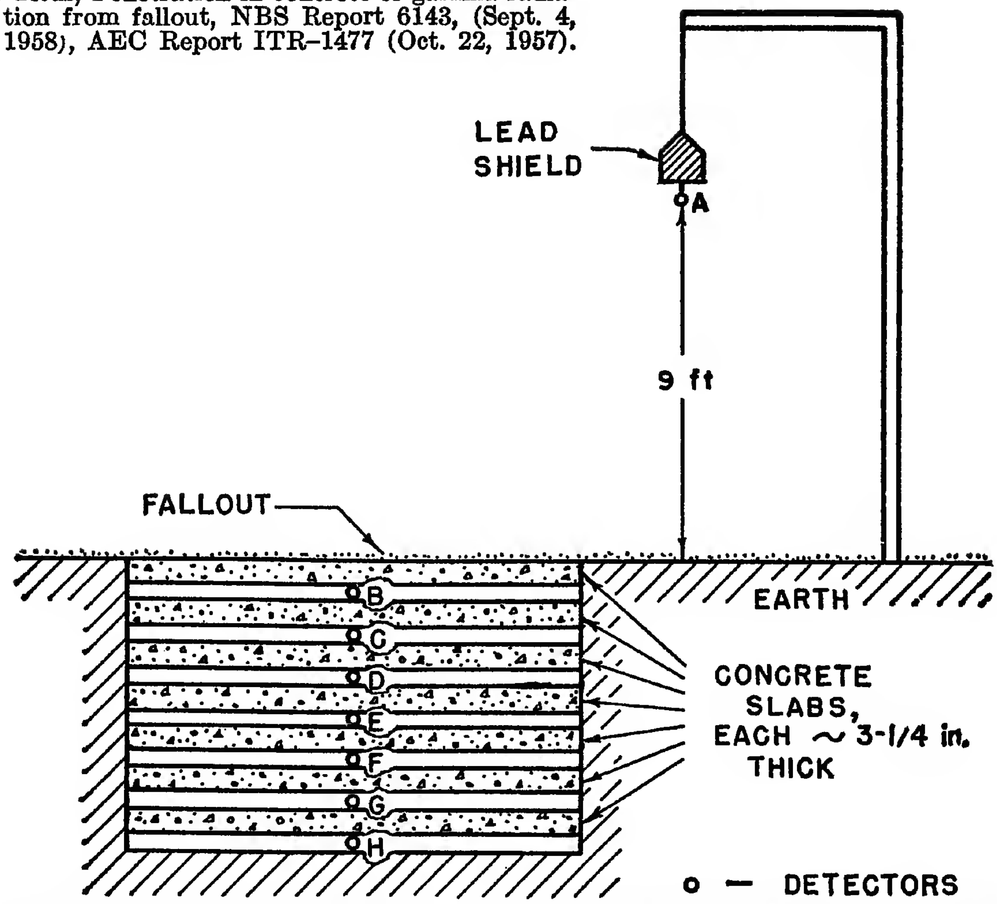
Sandia National Laboratories

ATTENUATION FACTORS FOR GAMMA RAYS FROM FISSION PRODUCTS AS A FUNCTION OF SHIELD THICKNESS FOR INDICATED MATERIALS*

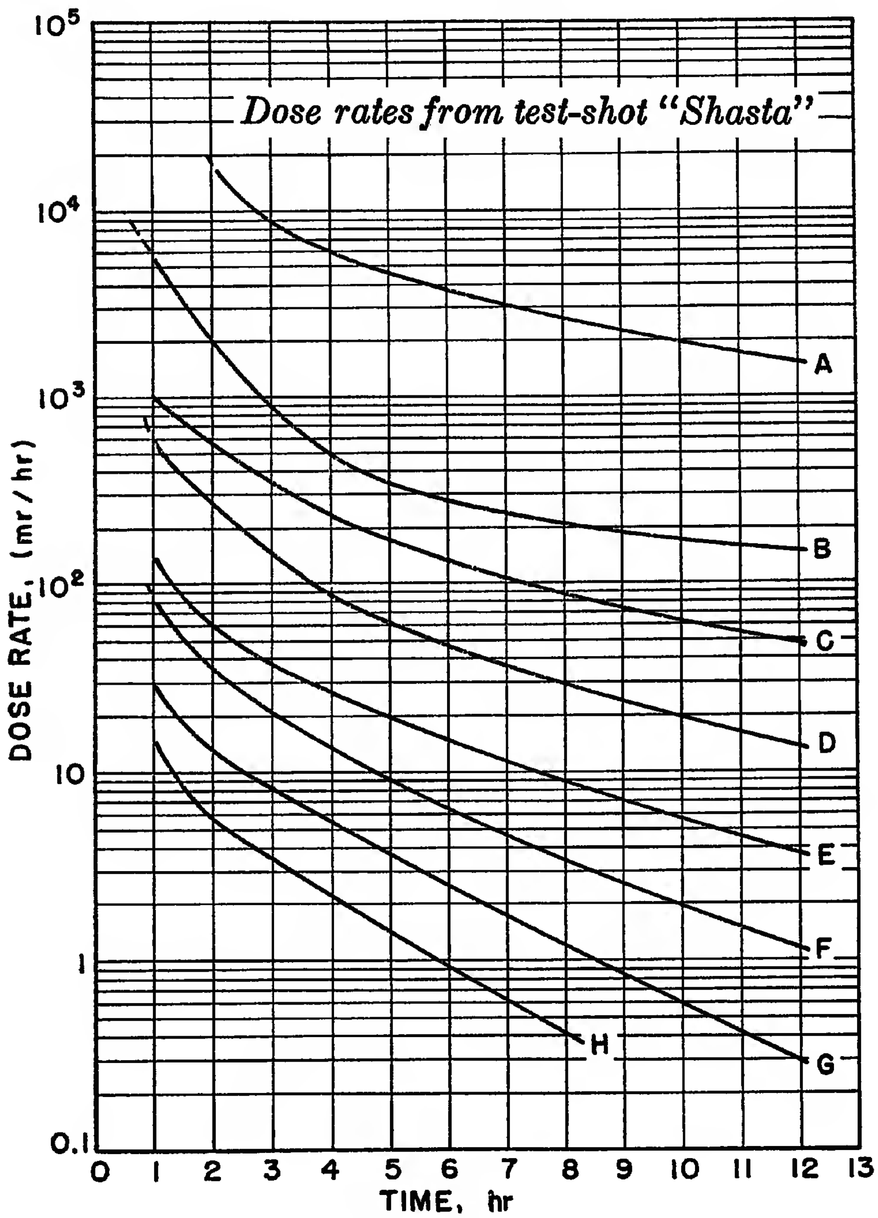
	Shield thickness for indicated materials, in.					
Attenuation factor	Lead (710 lb/cu ft)	Iron and steel (490 lb/cu ft)	Concrete (144 lb/cu ft)	Earth (100 lb/cu ft)	Water (62.4 lb/cu ft)	Wood (Fir) (3.4 lb/cu ft)
2	0.28	0.7	2.5	3.5	4.8	9.2
4	0.64	1.8	6.6	8.9	13	25
10	1.0	2.7	9.7	13	19	36
50	1.6	4.2	14	20	29	55
100	1.9	4.8	16	23	33	62
1,000	2.7	6.8	22	32	45	88
10,000	3.5	8.8	27	39	56	110
100,000	4.3	11	32	46	70	140

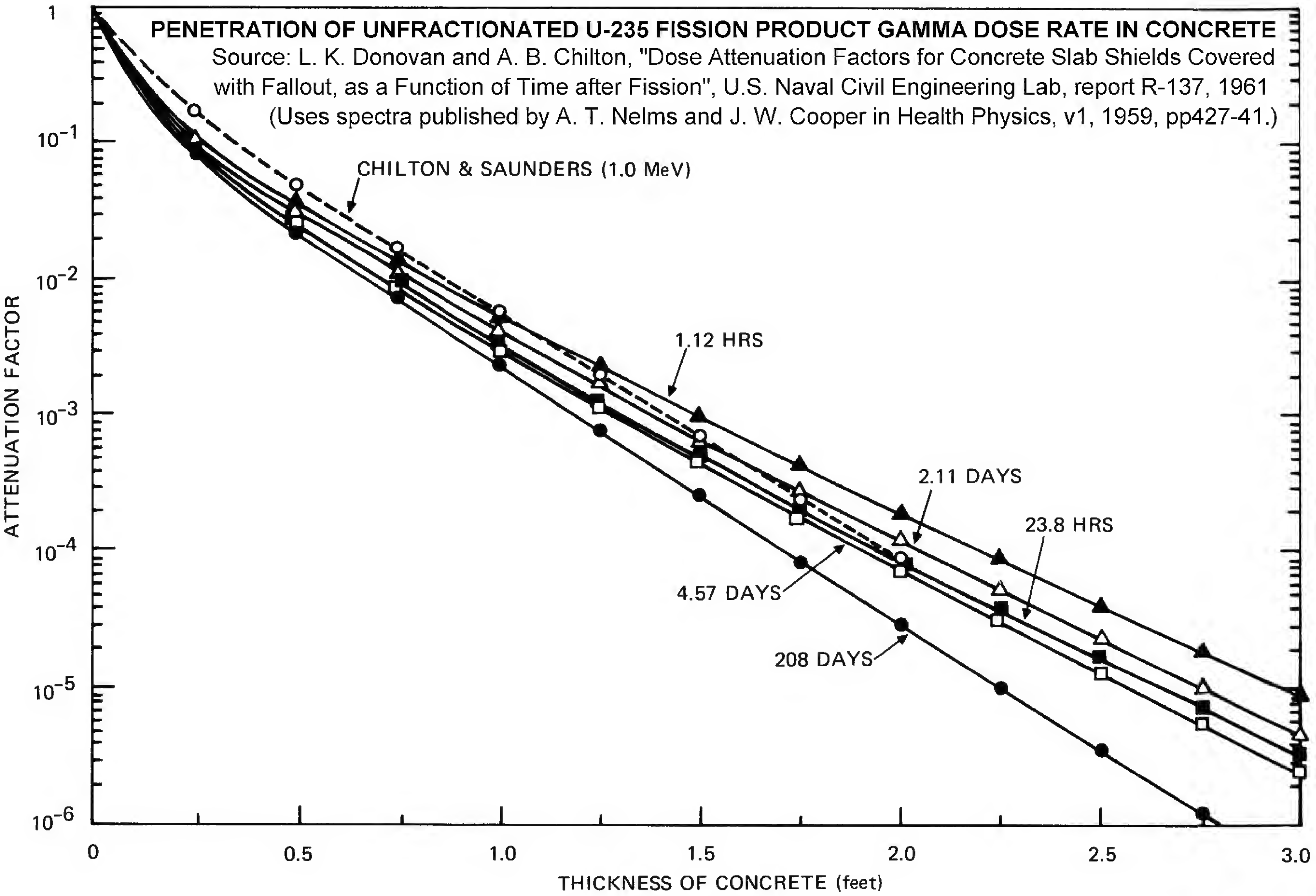
*Data from *The Effects of Nuclear Weapons.*

F. Titus, Penetration in concrete of gamma radiation from fallout, NBS Report 6143, (Sept. 4, 1958), AEC Report ITR-1477 (Oct. 22, 1957).

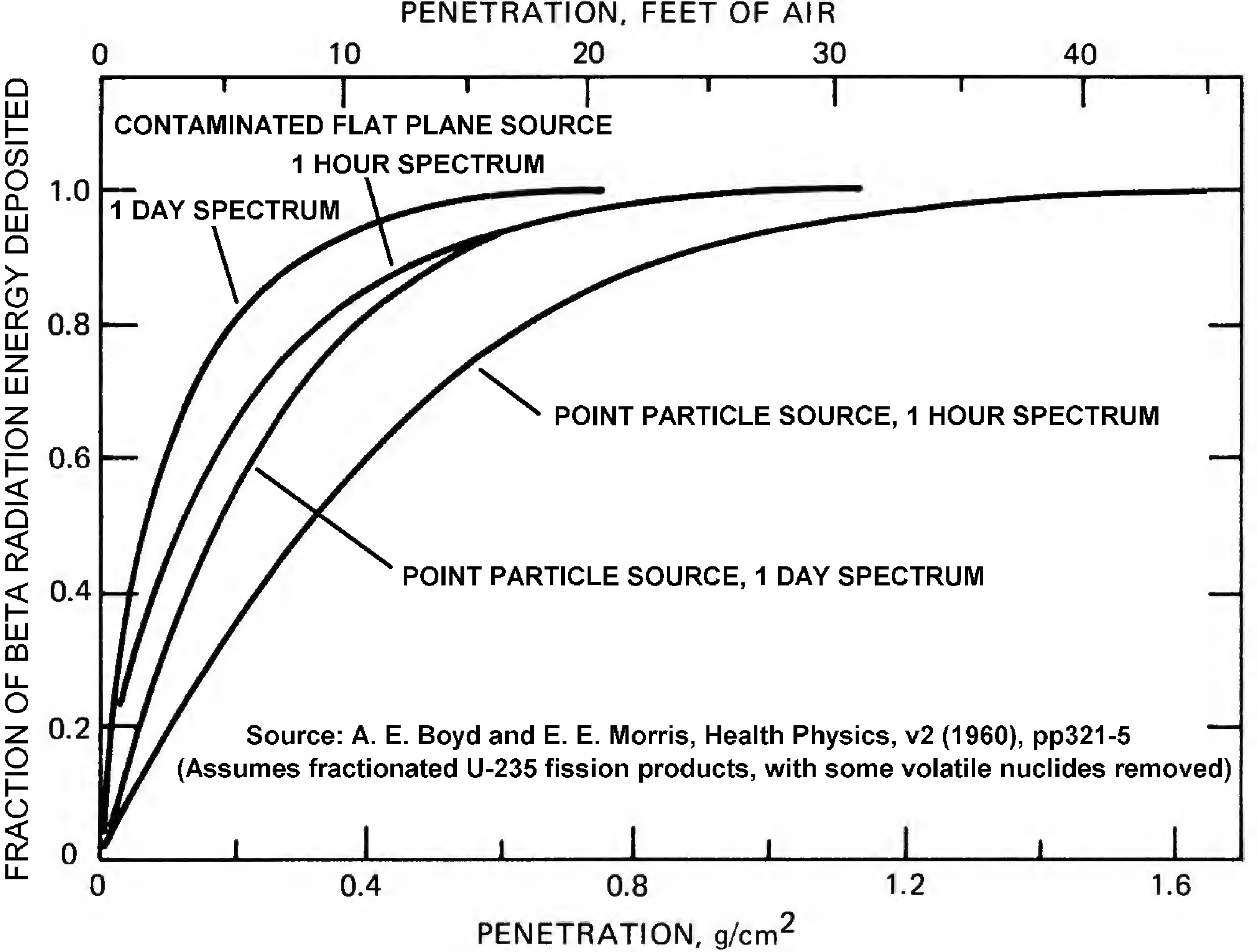


The lead shield prevents fallout material from settling directly on detector "A," while at the same time shielding against the intercepted material





PENETRATION OF UNFRACTIONATED U-235 FISSION PRODUCT GAMMA DOSE RATE IN CONCRETE
Source: L. K. Donovan and A. B. Chilton, "Dose Attenuation Factors for Concrete Slab Shields Covered with Fallout, as a Function of Time after Fission", U.S. Naval Civil Engineering Lab, report R-137, 1961
(Uses spectra published by A. T. Nelms and J. W. Cooper in Health Physics, v1, 1959, pp427-41.)
CHILTON & SAUNDERS (1.0 MeV)
1.12 HRS
2.11 DAYS
23.8 HRS
4.57 DAYS
208 DAYS
ATTENUATION FACTOR
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
THICKNESS OF CONCRETE (feet)
0
0.5
1.0
1.5
2.0
2.5
3.0


PENETRATION, FEET OF AIR
0
10
20
30
40
CONTAMINATED FLAT PLANE SOURCE
1 HOUR SPECTRUM
1 DAY SPECTRUM
POINT PARTICLE SOURCE, 1 HOUR SPECTRUM
POINT PARTICLE SOURCE, 1 DAY SPECTRUM
FRACTION OF BETA RADIATION ENERGY DEPOSITED
1.0
0.8
0.6
0.4
0.2
0
Source: A. E. Boyd and E. E. Morris, Health Physics, v2 (1960), pp321-5
(Assumes fractionated U-235 fission products, with some volatile nuclides removed)
0
0.4
0.8
1.2
1.6
PENETRATION, g/cm2

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Printed for the Cabinet. December 1954

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TOP SECRET Copy No.

C. (54) 389

9th December, 1954

UK NATIONAL ARCHIVES: CAB 129/72

CABINET

FALL-OUT

MEMORANDUM BY THE MINISTER OF DEFENCE

I attach a note on the effects of the explosion of a thermo-nuclear bomb. Its main purpose is to describe the conditions created by fall-out—the radio-active contamination which is caused when a bomb bursts at on near ground level. The effects of other forms of energy released by a thermo-nuclear explosion—blast and heat—are outlined briefly.

2. This analysis is founded on the latest scientific information we have. It accords with all that we have been able to find out about the effects of the experiments by the United States in the Pacific and elsewhere. It is also supported by a similar analysis carried out by the Canadians. We would naturally like to have consultation with the United States in order to confirm that the conclusions reached by our scientists are compatible with those to which American scientists have come. From the varied contacts which have taken place with the Americans, we have no reasons to suppose that they would dissent on any point of substance from the analysis here given. But we cannot be certain of this until our formal request to the Department of Defence for co-operation and consultation in this field has been submitted to Congress for approval as required by the 1954 Atomic Energy Act. I understand that the United States Administration hope to lay the proposed Agreement before Congress in January. In such event the consequent constitutional processes should be completed in time to permit of joint consultation with us early next spring.

3. This means that the United States Authorities will continue to be debarred from entering into the discussions, which they as well as we agree are necessary, until after the defence estimates are presented to Parliament for 1955–56. Regrettable as this is, we should, I think, consider whether there are not certain aspects on which an approach should be made in the meantime. We need, for example, to discuss with them the revised strategic concept of the Chiefs of Staff and the implications which this has for Allied defence policy. Even more urgent is the need to consult with them on the political problems with which they as well as we are faced in presenting to the public the changes which the advent of the hydrogen bomb imposes on our respective preparations for defence.

4. There are indications that the United States Government are now considering the political implications of the hydrogen bomb for their home front. But we cannot be sure that they will consult us before making any public announcement about its impact on their defence plans, and, if they should announce their policy without prior consultation with us, we must be able to show that we are not unprepared for these problems in our new defensive policy. Moreover, by

initiating discussions with the Americans on the aspects which I have suggested, we should avoid giving the impression that the purpose of our approach is to obtain information about atomic energy, which they consider themselves unable to give us without the approval of Congress.

5. Valuable though United States confirmation of our conclusions about fall-out would be, our scientists are confident that the margin of possible error in the attached analysis is not wide enough to invalidate its substance. Moreover, the significance of fall-out for our defence planning would not be materially affected even if the consequences were later found to be somewhat less bleak than they appear now. There are no grounds, therefore, for deferring the necessary re-orientation of our planning until we can check our own conclusions with the Americans.

6. It is, I think, evident that this new information must have a revolutionary effect over a wide range of our war plans, both military and civil. Thought is already being given to its implications by the limited circle of Ministers and officials to whom this scientific appreciation is known. But we cannot ensure that all our preparations will be properly adjusted to allow for this new factor without widening the limit within which knowledge of the new implications has so far been confined. Unless this is arranged much of our planning is bound to get out of gear.

7. If this is done, however, we must accept some risk that people may come to know quite soon that the Government are planning on this new hypothesis. Admittedly, almost all the conclusions in the attached note could be reached by diagnosis of material which has been published. But much of the present indifference of the public would vanish if they found that the Government had adopted this basis for their defence plans.

8. I therefore propose that we should now consider:—

(*a*) The extent to which it is desirable to issue guidance on the implications of fall-out to Departments concerned with defence preparations.

(*b*) The manner in which the implications of fall-out for our defence policy should be presented to the public, bearing in mind that the facts of this subject are in large measure already available to them and that the radical changes in Government plans require to take account of fall-out cannot long be concealed from the public once they are applied to our defence preparations.

(*c*) The form and timing of an approach to the United States Government on problems raised in this paper. The emphasis on the initial discussions should, I suggest, be on the common political problems which are raised for the Americans as well as ourselves by the development of thermo-nuclear weapons, and on the importance of harmonising the presentation to the public of the changes which we must each make in our defence policy. It would also be valuable to exchange views with the Americans, initially perhaps on the Chiefs of Staff level, on the implications of the latest developments for the strategic policy of the Western alliance.

H. M.

Ministry of Defence, S.W. 1,
7th December, 1954.

ANNEX

EFFECTS OF THE EXPLOSION OF A THERMO-NUCLEAR BOMB

The explosion of a hydrogen bomb releases energy in three forms—blast, heat and nuclear radiation. Their relative importance depends on the distance of the bomb from the surface at the moment of explosion. Broadly speaking, the effects of blast and heat are comparatively local in all cases, whereas those of radiation may be very widespread.

2. *Size of the Bomb.*—There is no technical limitation to the yield of this weapon. The analysis which follows is related throughout to a 10-megaton bomb (10 M.T.). The highest yield achieved in the United States experiments to date is 30 M.T. The area affected by a bomb of this yield would be about 45 per cent. greater than in the case we are considering.

3. *Blast and Heat.*—Blast and heat are more intense from an air burst than from a ground burst. In dull weather damage from the heat wave is somewhat less extensive than in clear air. The blast and heat resulting from the explosion of a 10-M.T. bomb would cause destruction on about the following scale:—

	Air Burst 10 M.T. at 20,000 feet (Radius in miles)	Ground Burst 10 M.T. (Radius in miles)
(*a*) Surface devastation to ordinary brick houses	7½	5½
(*b*) Devastation to facilities and tunnels below ground	Nil	⅓ mile in radius and depth
(*c*) Major structural damage to brick houses	9	6¾
(*d*) Surface damage by fire on ordinary day	8–12	5–9

4. *Radiation.*—The initial radiation occurring within a few seconds of detonation of a bomb, whether air burst or ground burst, is probably confined within a radius of three or four miles. The area thus affected is therefore in any case devastated by heat and blast.

The residual radiation occurring as an after-effect of the explosion varies very greatly in its effects, according to the point of burst.

If the bomb bursts too high for the fire ball to reach ground level, the bulk of the radio-active materials are carried into suspension in the upper atmosphere. They are then so dispersed that they have no serious local effects when they eventually settle out.

But if the bomb bursts at or near the ground,* quantities of much heavier radio-active particles are carried for a while by the winds that blow in differing directions at different levels. The pattern of precipitation is irregular, varying with the speed and direction of the air currents in the area, but a high proportion of the fall-out occurs from very high levels where the winds are more constant in direction and speed. This tends to elongate the area of contamination in the direction of the winds there prevailing.

5. *Effects of Radiation on Life.*—No medical means of curing or even curbing the effects of radiation on human beings are yet known. On human beings the effects are cumulative over a considerable period, becoming lethal when a certain dosage has been absorbed. In the Marshall Islands natives on an atoll 110 miles from the explosion received about one-third of the lethal dose: Americans who remained in huts 150 miles downwind received over a tenth of the lethal dose. Both these groups were 20 miles off the main line of fall-out.

Symptoms of radiation sickness may not show for some days, or even weeks. But about one-fifth of the lethal dose produces temporary sickness, with increasing disability as absorption increases beyond this point.

On animals the direct effects are similar. (In the Marshall Islands all animal life was extinguished on an atoll 110 miles from the explosion.) Moreover, one

* The effects of an explosion on or under the sea are, broadly speaking, intermediate betw those of a ground burst and of an air burst bomb.

of the products of the explosion is radio-active strontium, which has an exceedingly low rate of decay. If it gains access to the body, it is deposited in the bones like calcium. Cattle which escaped other effects of radiation would become casualties if they ate grass, even in small quantities, which was contaminated in this way. Any milk they produced before they died would be unsafe for human consumption. Owing to the difficulty of arranging food and cover, most of the sheep and cattle in the contaminated area would be wiped out.

All growing crops subjected to serious contamination would have to be destroyed, though root crops might be safe if they could be harvested quickly without being infected by surface contamination in the process. Similarly, crops like beans might be safe, provided the pods could be removed without contaminating the beans themselves. Further investigation of the implications for agriculture is necessary, but it is certain that it would not be safe to use land contaminated with strontium for at least a year, and possibly for several years.

Radiation does not in general affect inert matter. Consequently, foodstuffs outside the inner lethal zone would almost certainly not be impaired, provided they were under cover and therefore not directly contaminated. It would be necessary to decontaminate the coverings to ensure the safety of people handling them and to prevent contamination of the contents.

6. *Area of Contamination.*—The superficial area which is contaminated will not vary much in size, but its shape will depend on the prevailing wind structure. The fall-out from a single ground-burst 10-M.T. bomb would cover an area of 5,000 to 6,000 square miles.

7. *Persistence.*—The radio-activity will decay with the lapse of time. The rate of decay is very rapid in the early stages, but flattens out thereafter and may persist for a long time in regions of initial high contamination.

8. *Degree of Contamination.*—In general, the density of contamination will diminish as the distance from the point of burst increases, but the shape of the contour indicating any particular rate of contamination will depend on the prevailing wind structure.

There will be an inner zone of approximately 270 square miles in area (larger than Middlesex), in which radiation will be so powerful that all life will be extinguished, whether in the open or in houses. Because of the persistence of the radio-active contamination in this inner zone, general relief measures would be virtually impossible for some weeks, and possibly months. People in specially deep shelters with their own supply of uncontaminated food and water would have some chance of survival, provided they were not entombed by other effects of the explosion. Even so, for at least a week it would not be safe for them to attempt to emerge and leave the area. Fires in this area would have to be left to burn themselves out.

Outside this central zone, the density of radiation will diminish progressively with distance from the point of burst, but the rate of diminution in any particular direction depends on the prevailing wind. Within an area of about 3,000 miles, which with a steady 20-knot wind would be 170 miles long in the direction of the wind and over 20 miles wide in places, exposure in the open on the first day might easily be fatal. Rescue operations could commence on the outer fringes on the second day and thereafter proceed with gathering momentum but the greater part of the area would be immobilised for several days. Survival in this area depends on cover. The efficiency of the cover depends on the weight of the screening material. A thickness of 12 inches of earth would reduce the radiation dosage rate by a factor of about 15. Suitably screened shelter in an ordinary well-bricked house can reduce the dosage rate by a factor as high as 20.

There will be an outer area of 2,000–3,000 square miles in which there is a danger of radiation sickness if no precautions are taken. In general, it would be sufficient for people to stay indoors for about 12 hours after the onset of contamination. As this depends on the speed of the wind, fall-out will not occur until 8–24 hours after the burst, and it might therefore be possible to move some people out of the main path which fall-out was expected to follow, should such a step be considered desirable.

9. It will be clear from the above that, if there is more than one burst within a period of days, the wind structure might be such as to cause an overlapping of the contaminated areas. In such case, there might well be isolated pockets of high density contamination at considerable distances from the explosions.

HOME OFFICE
SCOTTISH HOME DEPARTMENT

MANUAL OF CIVIL DEFENCE

Volume I

PAMPHLET No. 1

NUCLEAR WEAPONS

LONDON
HER MAJESTY'S STATIONERY OFFICE
1956

Practical protection

88 Large buildings with a number of storeys, especially if they are of heavy construction, provide much better protection than small single-storey structures (see Figure 4). Houses in terraces likewise provide much better protection than isolated houses because of the shielding effect of neighbouring houses.

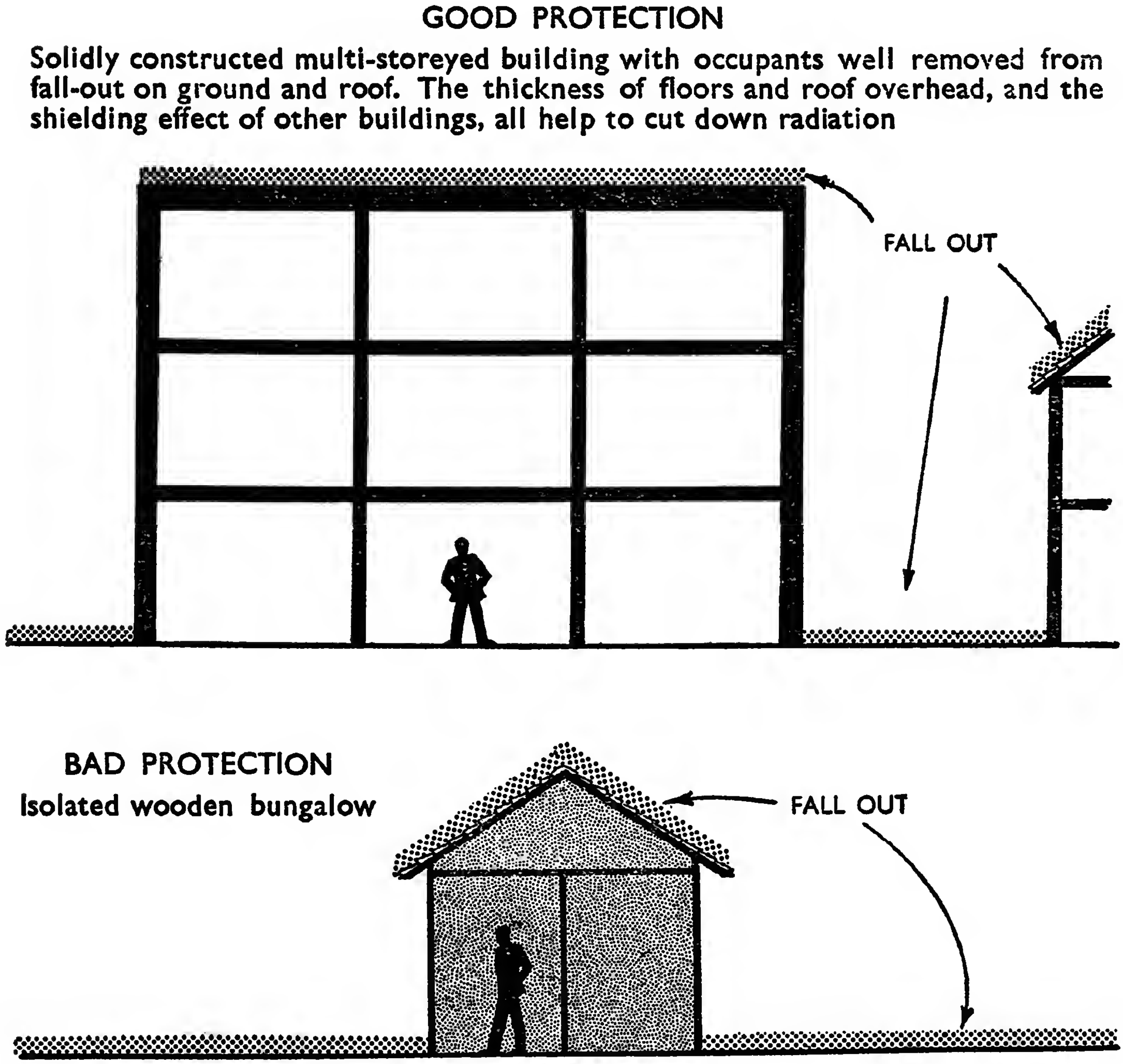


FIGURE 4

Examples of good and bad protection afforded by buildings against fall-out.

89 It is estimated that the protection factor (the factor by which the outside dose has to be divided to get the inside dose) of a ground floor room in a two-storey house ranges from 10 to about 50, depending on wall thickness and the shielding afforded by neighbouring buildings. The corresponding figures for bungalows are about 10–20, and for three-storey houses about 15–100. An average two-storey brick house in a built-up area gives a factor of 40, but basements, where the radiation from outside the house is attenuated by a very great thickness of earth, have protection factors ranging up to 200–300. A slit trench with even a light cover of boards or corrugated iron without earth overhead gives a factor of 7, and if 1 ft. of earth cover is added the

factor rises to 100. If the trench can be covered with 2 or 3 feet of earth then a factor of more than 200–300 can be obtained (see Figure 5).

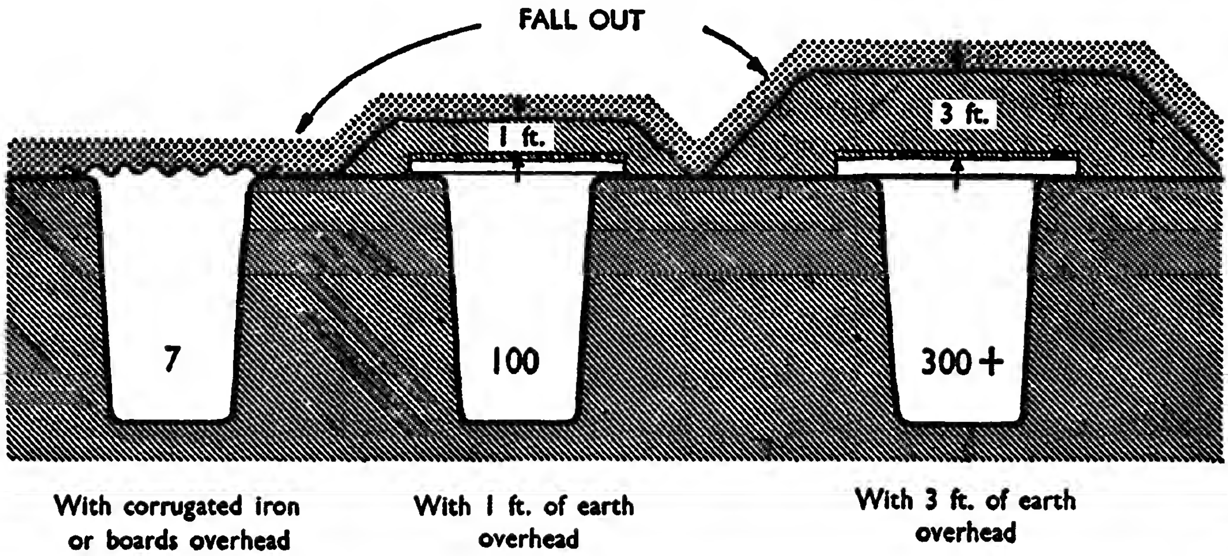


FIGURE 5
Protection factors in slit trenches (the factor by which the outside dose is divided to get the inside dose).

Choosing a refuge room

90 In choosing a refuge room in a house one would select a room with a minimum of outside walls and make every effort to improve the protection of such outside walls as there were. In particular the windows would have to be blocked up, e.g. with sandbags. Where possible, boxes of earth could be placed round an outside wall to provide additional protection, and heavy furniture (pianos, bookcases etc.) along the inside of the wall would also help. A cellar would be ideal. Where the ground floor of the house consists of boards and timber joists carried on sleeper walls it may be possible to combine the high protection of the slit trench with some of the comforts of the refuge room by constructing a trench under the floor.

Once a trap door had been cut in the floor boards and joists and the trench had been dug, there would be no further interference with the peace-time use of the room.

Estimated under-cover doses in the fall-out area

91 Taking an average protective factor of 40 for a two-storey house in a built-up area, the doses accumulated in 36 hours for the ranges referred to in the U.S. Atomic Energy Commission Report (paragraph 84) would have been:—

190 miles downwind	$7\frac{1}{2}$r	15 Megatons
160 ,, ,,	$12\frac{1}{2}$r	Bravo 1954
140 ,, ,,	20r	

which are all well below the lowest figure of 25r referred to in Table 1. At closer ranges along the axis of the fall-out, the doses accumulated in 36 hours would have been much higher, but over most of the contaminated area—with this standard of protection—the majority of those affected would have been saved from death, and even from sickness, by taking cover continuously for the first 36 hours.

5. **Radiation sickness**

Assume dose incurred in a single shift (3–4 hours) by the "average" man, over the whole body:—

25 roentgens	—No obvious harm.
100 ,,	—Some nausea and vomiting.
500 ,,	—Lethal to about 50 per cent. people (death up to 6 weeks later).
800 ,, or more	—Lethal to all (death up to 6 weeks later).

Note: If dose spread uniformly over 2–3 days, then 60 roentgens could be incurred with no more effect than 25 roentgens in a single exposure of 3–4 hours.

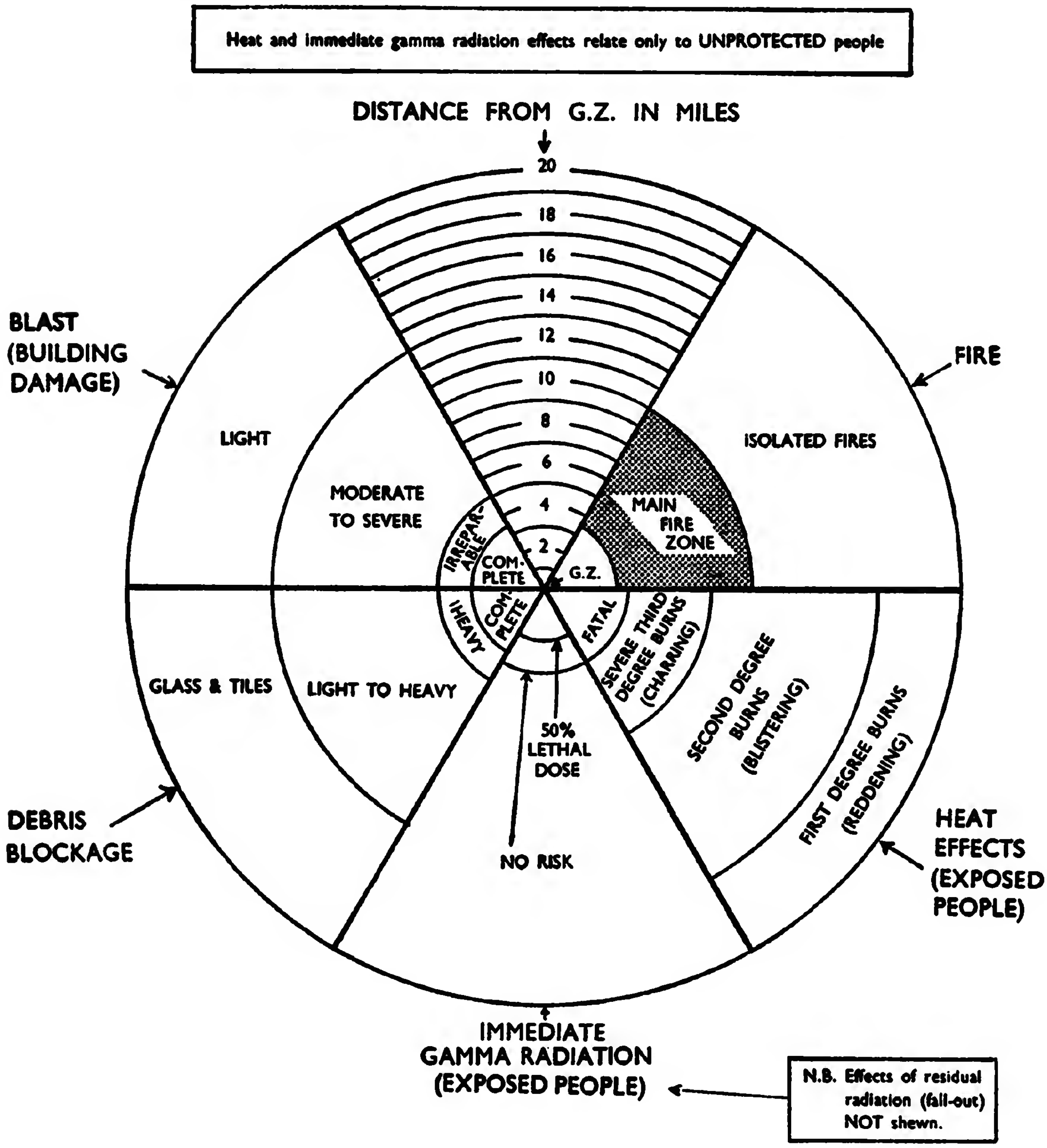
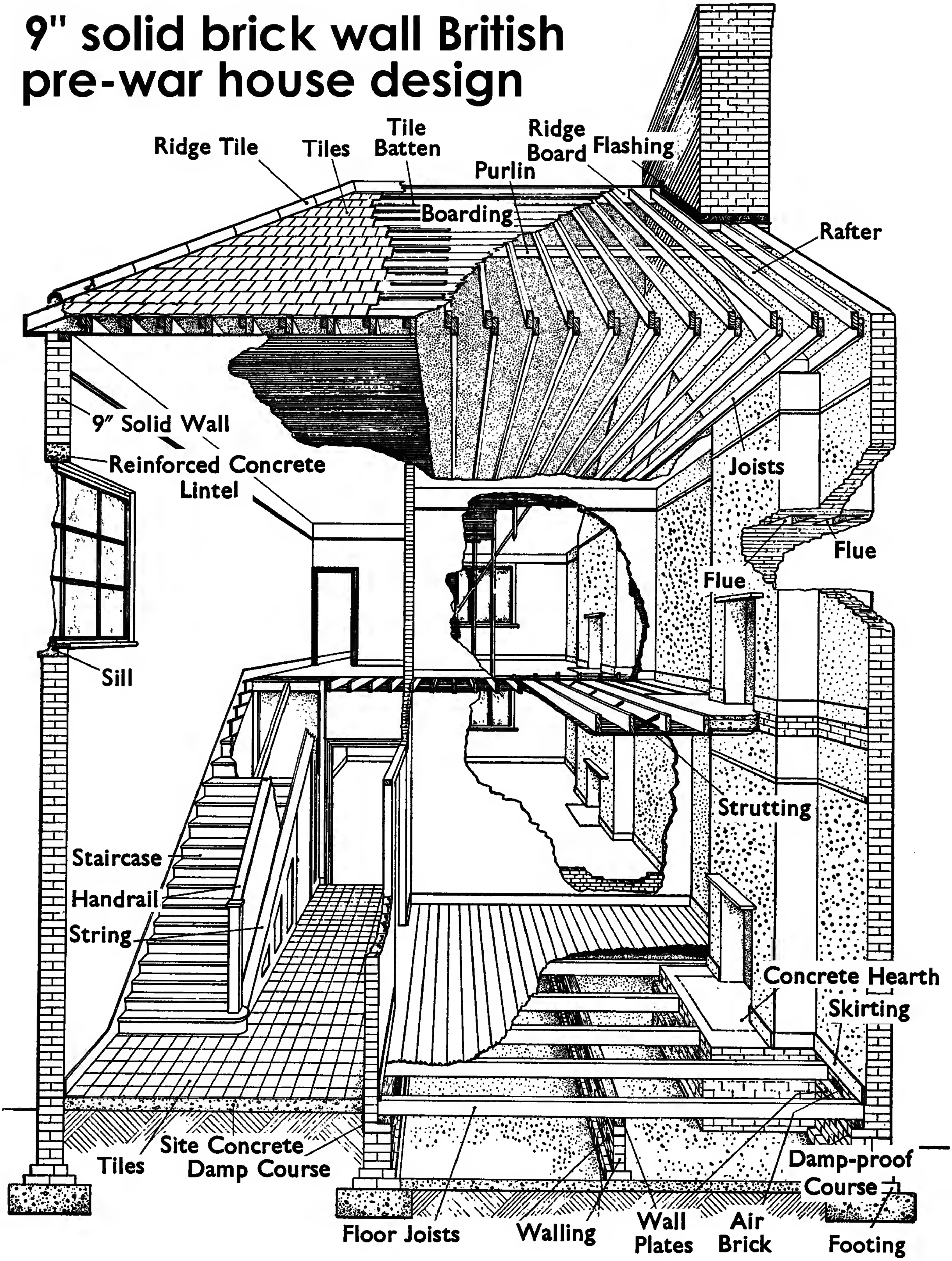


FIGURE 11

Combined effects (excluding residual radioactivity) from a 10 megaton ground burst bomb. Heat and immediate gamma radiation effects relate only to UNPROTECTED people.

9" solid brick wall British pre-war house design



HOME OFFICE
SCOTTISH HOME DEPARTMENT

MANUAL OF CIVIL DEFENCE

Volume I

PAMPHLET No. 2

RADIOACTIVE FALL-OUT

PROVISIONAL SCHEME OF PUBLIC CONTROL

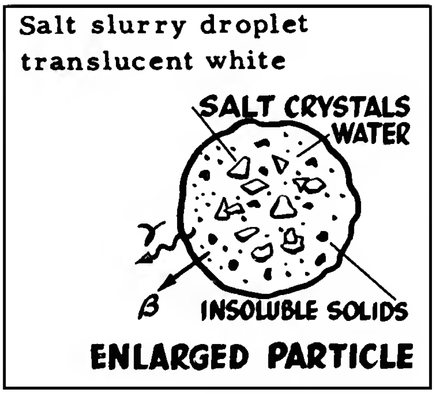
LONDON
HER MAJESTY'S STATIONERY OFFICE
1956

Radioactive Fall-out—Summary of Provisional Control Zones

Zone	Definition of Zone Boundaries	Range of Cumulative Doses in open at 48 hours	Summary of permissible and recommended action	Range of Cumulative Doses assuming observance of control rules
W	Outer: Limit of area placed under "Black Warning" (*see* Footnote). Inner: 0·3 r.p.h. at 48 hrs.	Up to 80r	Complete release from refuge as soon as dose-rate fell to 0·3 r.p.h. or, if the rate had not reached that figure, when fall-out was complete.	At 48 hrs. Below 2r
X	Outer: 0·3 r.p.h. at 48 hrs. Inner: 3 r.p.h. at 48 hrs.	80–800r	Qualified release from refuge after 48 hrs.—indoor workers to follow normal occupations, but not to exceed 4 hrs. per day in the open. Outdoor workers to work half shifts for next five days. At the end of this period the zone would be normal, except that all would be advised to be out of doors as little as possible and not in any case to exceed 8 hrs. per day in the open for the next three months.	At 48 hrs. 2-20r At 7 days 6-60r At 5 wks. 12-120r At 3 mths. 14-145r
Y	Outer: 3 r.p.h. at 48 hrs. Inner: 10 r.p.h. at 48 hrs.	800-2,800r	Release from refuge under stringent control after 48 hrs. For the next 12 days people should not leave their refuge for longer than necessary. Time in the open should not exceed 2 hrs. per day and time under cover, but not in refuge, a further 8 hrs. On this basis essential indoor workers should be able to get to their places of work, but outdoor work would remain suspended; a relaxation would be possible after the first fortnight and further easement in another three weeks. For the rest of the first year, however, people in this zone should not exceed 8 hrs. a day in the open.	At 48 hrs. 20-70r At 14 days 50-170r At 5 wks. 70-240r At 3 mths. 95-330r
Z	10 r.p.h. at 48 hrs.	Above 2,800r	All movement outside refuge accommodation in this zone would be dangerous. People should remain in refuge until instructions for clearance were given—they should then leave the zone by the quickest available route if they had means of transport or wait in their refuge to be collected if they had not. The clearance operation might start after 48 hrs. and removal from the zone would be for at least 3 months.	At 48 hrs.—Above 70r

The initial Zone W boundary would be defined by the boundaries of a series of warning districts on the flanks of the fall-out. After 48 hrs. Zone W would for public control purposes have disappeared: its outer boundary would have moved during the period to coincide with the outer boundary of Zone X.

The question of defining an area extending in some places beyond Zone W in which there might be an agricultural hazard is being studied.



WATER SURFACE BURST

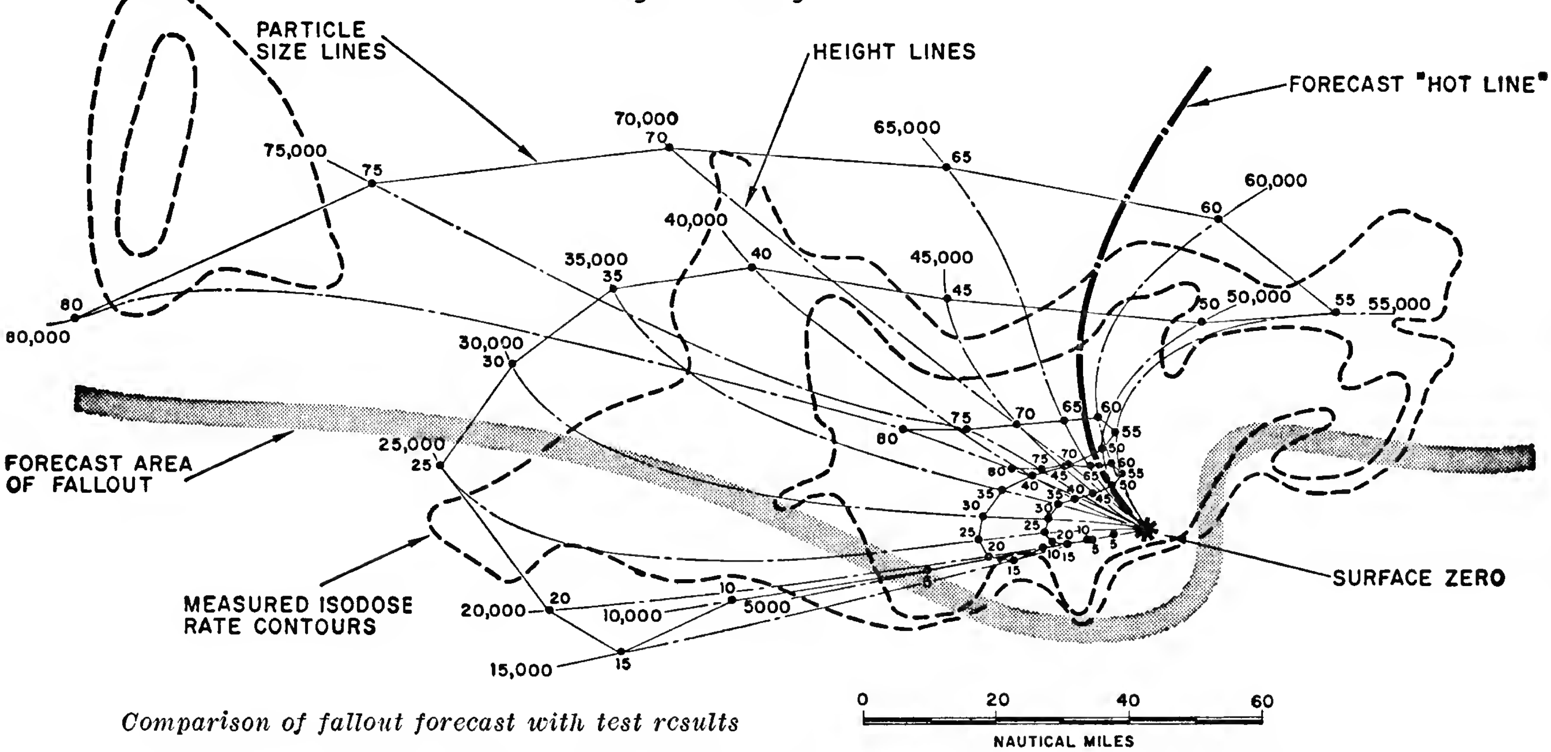
A Fallout Forecasting Technique With Results Obtained at the Eniwetok Proving Ground

E. A. Schuert, USNRDL TR–139, United States Naval Radiological Defense Laboratory, San Francisco, Calif.

Time variation of the winds aloft

In most of the observations made at the Eniwetok Proving Ground, the winds aloft were not in a steady state. Significant changes in the winds aloft were observed in as short a period as 3 hours. This variability was probably due to the fact that proper firing conditions which required winds that would deposit the fallout north of the proving ground, occurred only during an unstable synoptic situation of rather short duration.

4.5 megaton Navajo



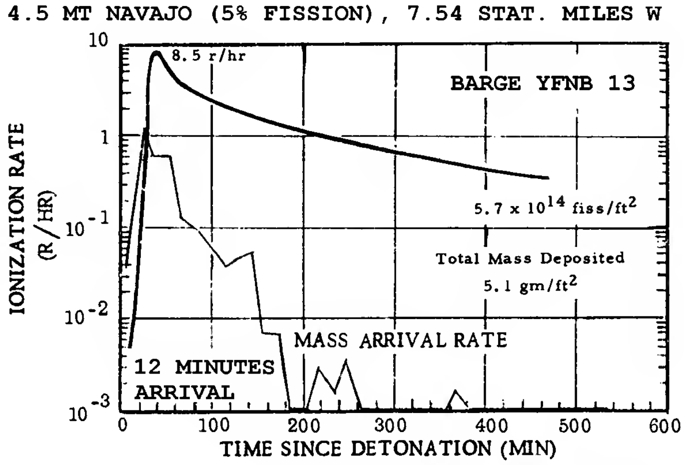
Comparison of fallout forecast with test results

HEIGHT LINE = DESTINATIONS FOR A FIXED HEIGHT OF ORIGIN FOR VARIOUS SIZES

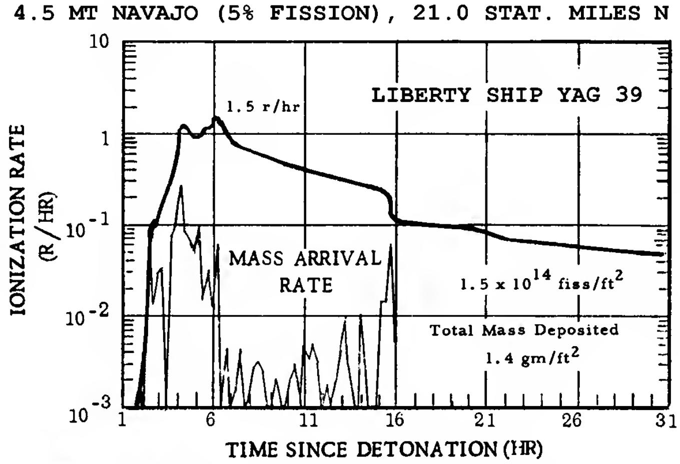
SIZE LINE = DESTINATIONS FOR A FIXED PARTICLE SIZE FROM VARIOUS HEIGHTS

HOT LINE = HEIGHT LINE FROM BASE OF MUSHROOM DISC (MAXIMUM FALLOUT)

4.5 MT NAVAJO (5% FISSION), 7.54 STAT. MILES W



4.5 MT NAVAJO (5% FISSION), 21.0 STAT. MILES N



Triffet, T. and LaRiviere, P. D.; Characterization of Fallout, Project 2.63

LAND SURFACE BURST

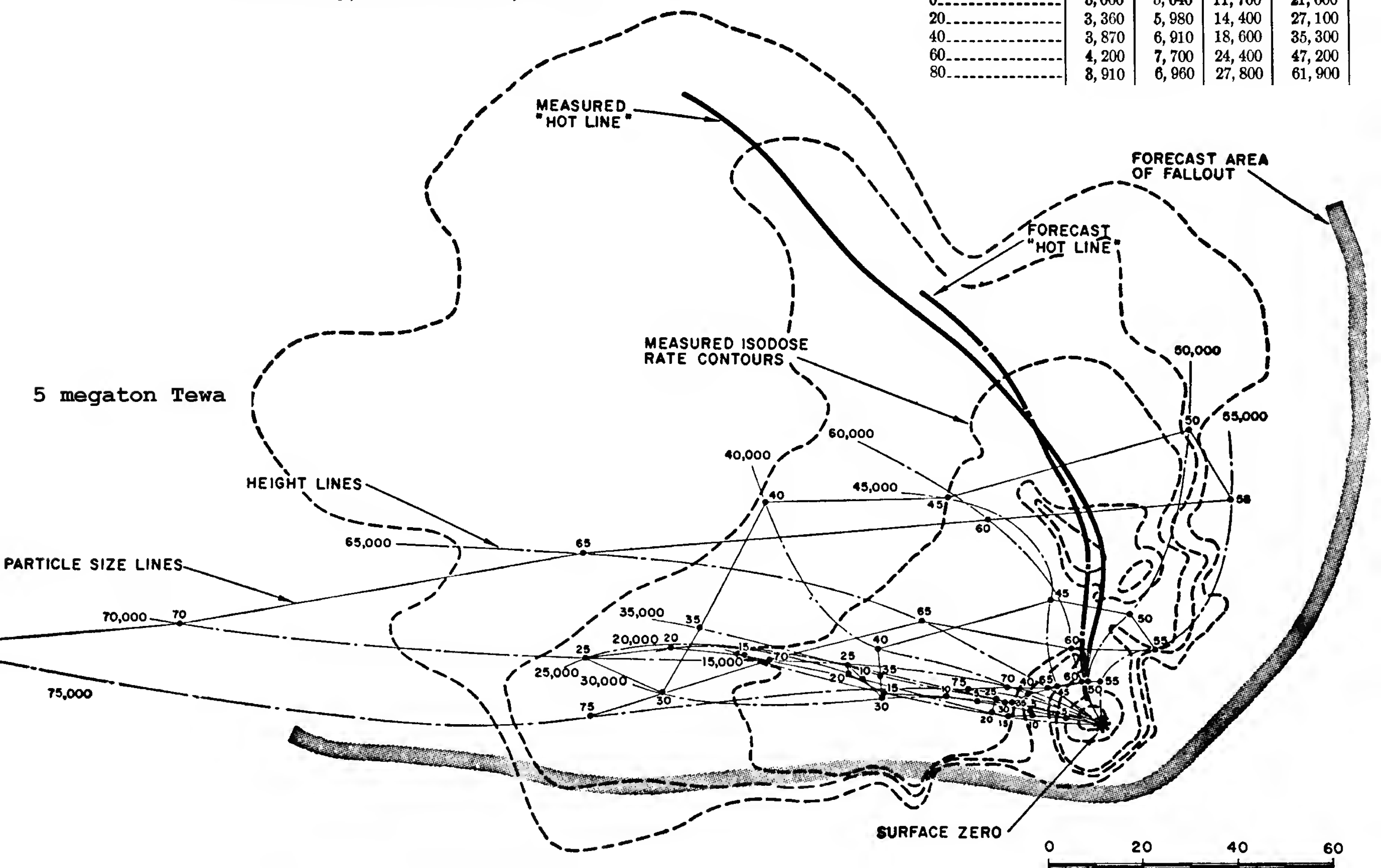
A Fallout Forecasting Technique With Results Obtained at the Eniwetok Proving Ground

E. A. Schuert, USNRDL TR–139, United States Naval Radiological Defense Laboratory, San Francisco, Calif.

2.36 g/cu cm irregular in shape

Falling speeds (feet/hour)

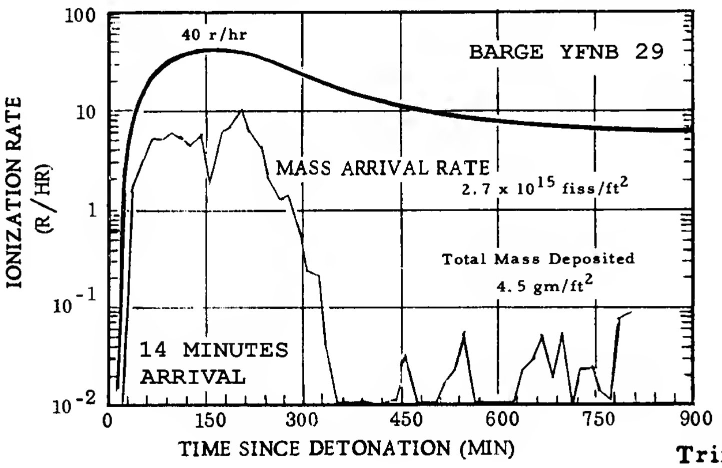
Altitude	75 μ	100 μ	200 μ	350 μ
0	3,060	5,040	11,700	21,600
20	3,360	5,980	14,400	27,100
40	3,870	6,910	18,600	35,300
60	4,200	7,700	24,400	47,200
80	3,910	6,960	27,800	61,900



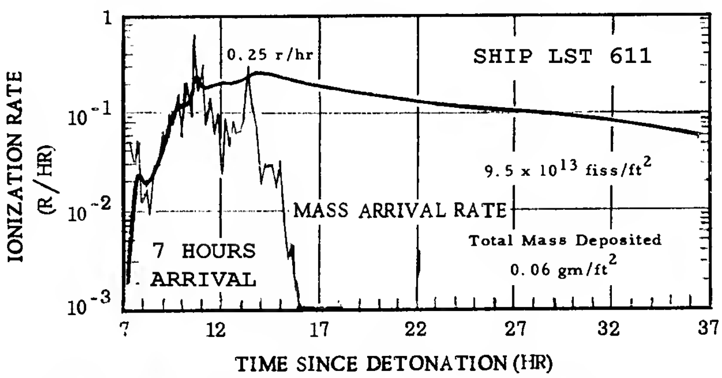
Comparison of fallout forecast with test results

HEIGHT LINE = DESTINATIONS FOR A FIXED HEIGHT OF ORIGIN FOR VARIOUS SIZES
SIZE LINE = DESTINATIONS FOR A FIXED PARTICLE SIZE FROM VARIOUS HEIGHTS
HOT LINE = HEIGHT LINE FROM BASE OF MUSHROOM DISC (MAXIMUM FALLOUT)

5 MT TEWA (87% FISSION), 7.84 STAT. MILES WSW



5 MT TEWA (87% FISSION), 59.3 STAT. MILES NW



Triffet, T. and LaRiviere, P. D.; Characterization of Fallout

WT-1316 (EX)
EXTRACTED VERSION

OPERATION REDWING

Project 2.62a
Fallout Studies by Oceanographic Methods

Pacific Proving Grounds

May - July, 1956

Defense Atomic Support Agency

Sandia Base, Albuquerque, New Mexico

February 6, 1961

NOTICE

This is an extract of **WT-1316, Operation REDWING, Project 2.62a,** which remains classified **Secret/ Restricted Data** as of this date.

Extract version prepared for:

Director
DEFENSE NUCLEAR AGENCY
Washington, D.C. 20305

1 February 1980

TABLE 2.11

	Navajo	Tewa
Total Yield, Mt	4.50	5.01
Fission proportion	5%	87%

H + 1 Hour Dose Rate (r/hr)	Area (mi^2) Within Contour	
1,000	25	450
500	55	1,050
300	80	1,550
100	310	3,500
Two-day Dose, R	**Area (mi^2) Within Contour**	
1,000	20	520
500	30	1,050
300	45	1,500
100	350	3,000

CLEAN BOMB: 3.53 MT (15% FISSION) ZUNI

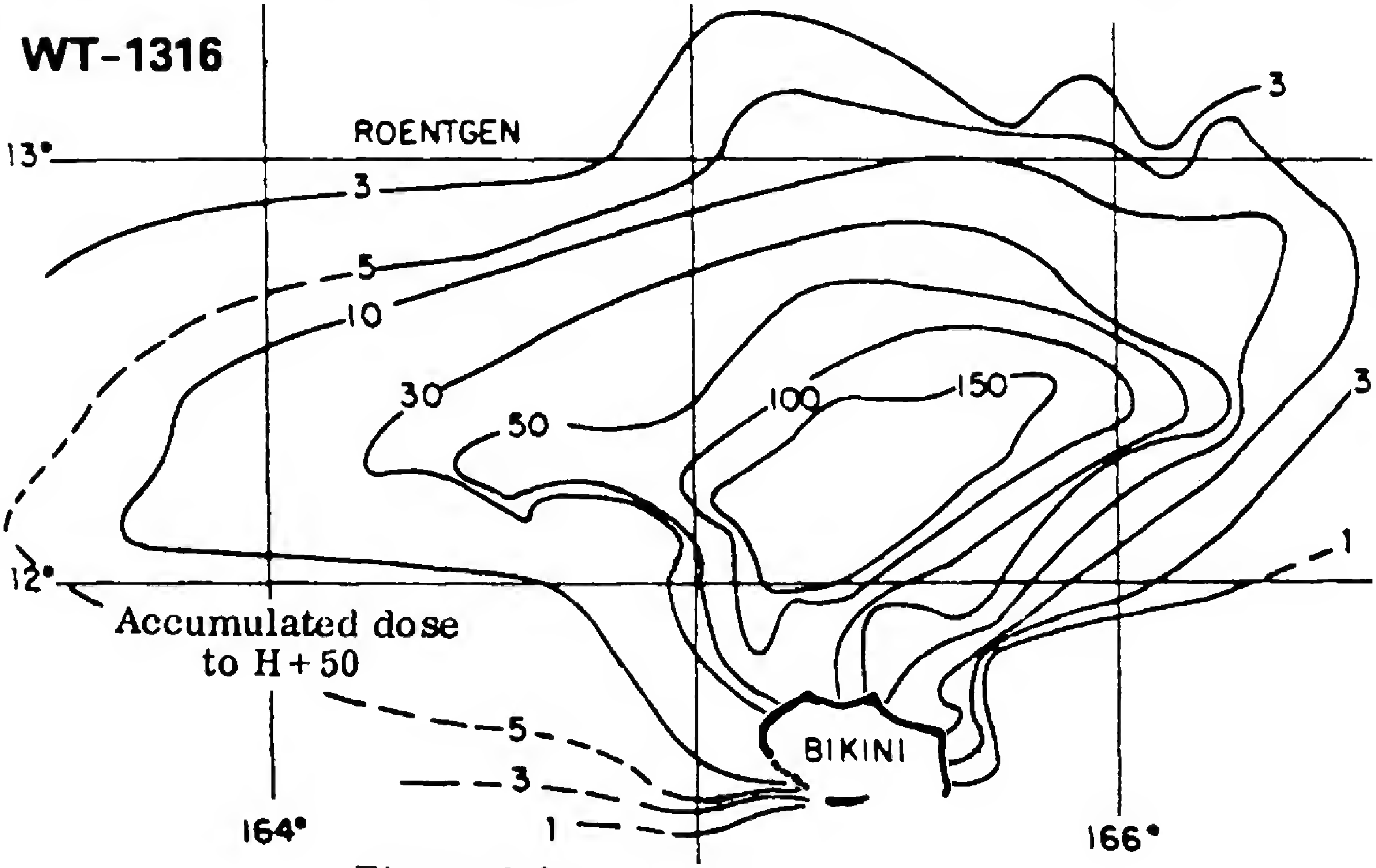


Figure 2.37

DIRTY BOMB: 5.01 MT (87% FISSION) TEWA

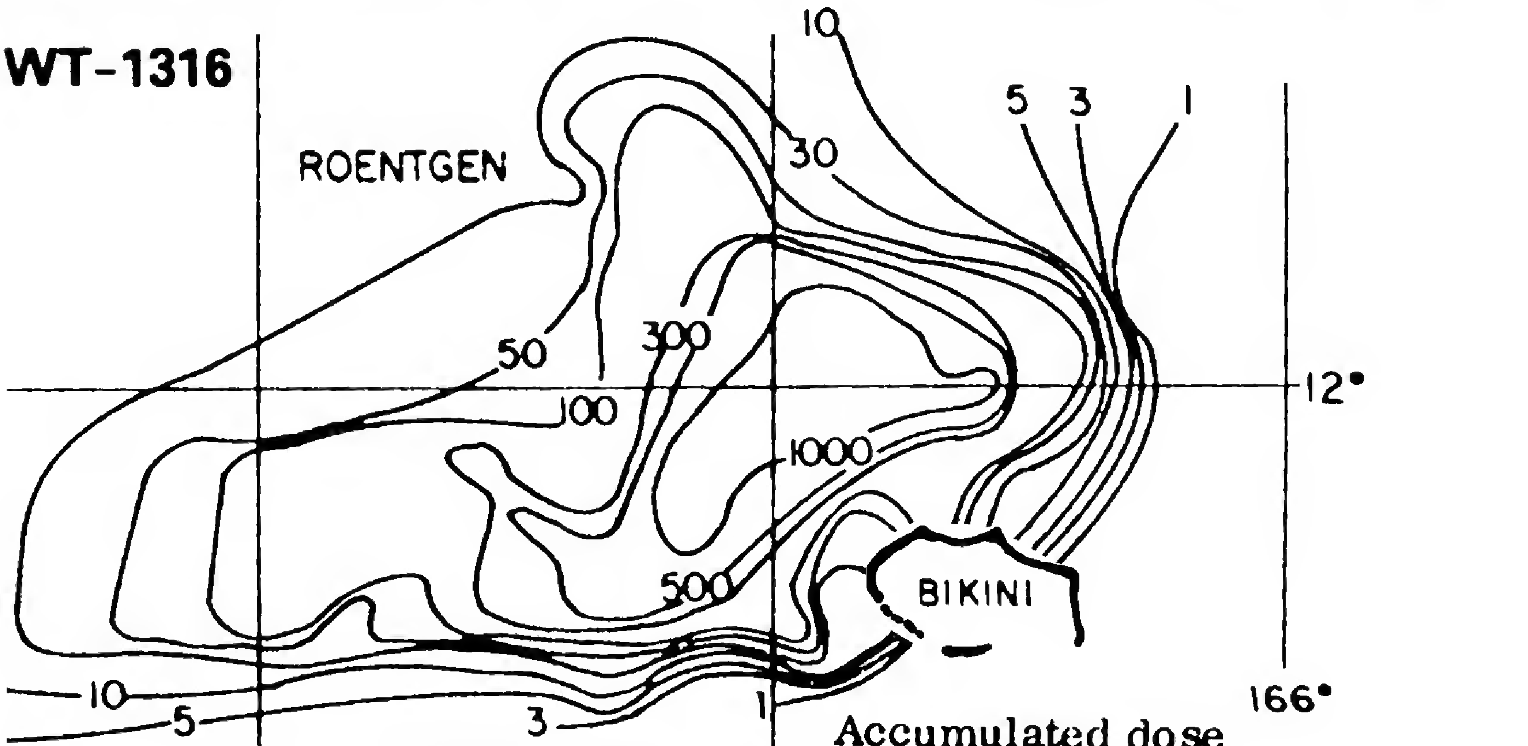
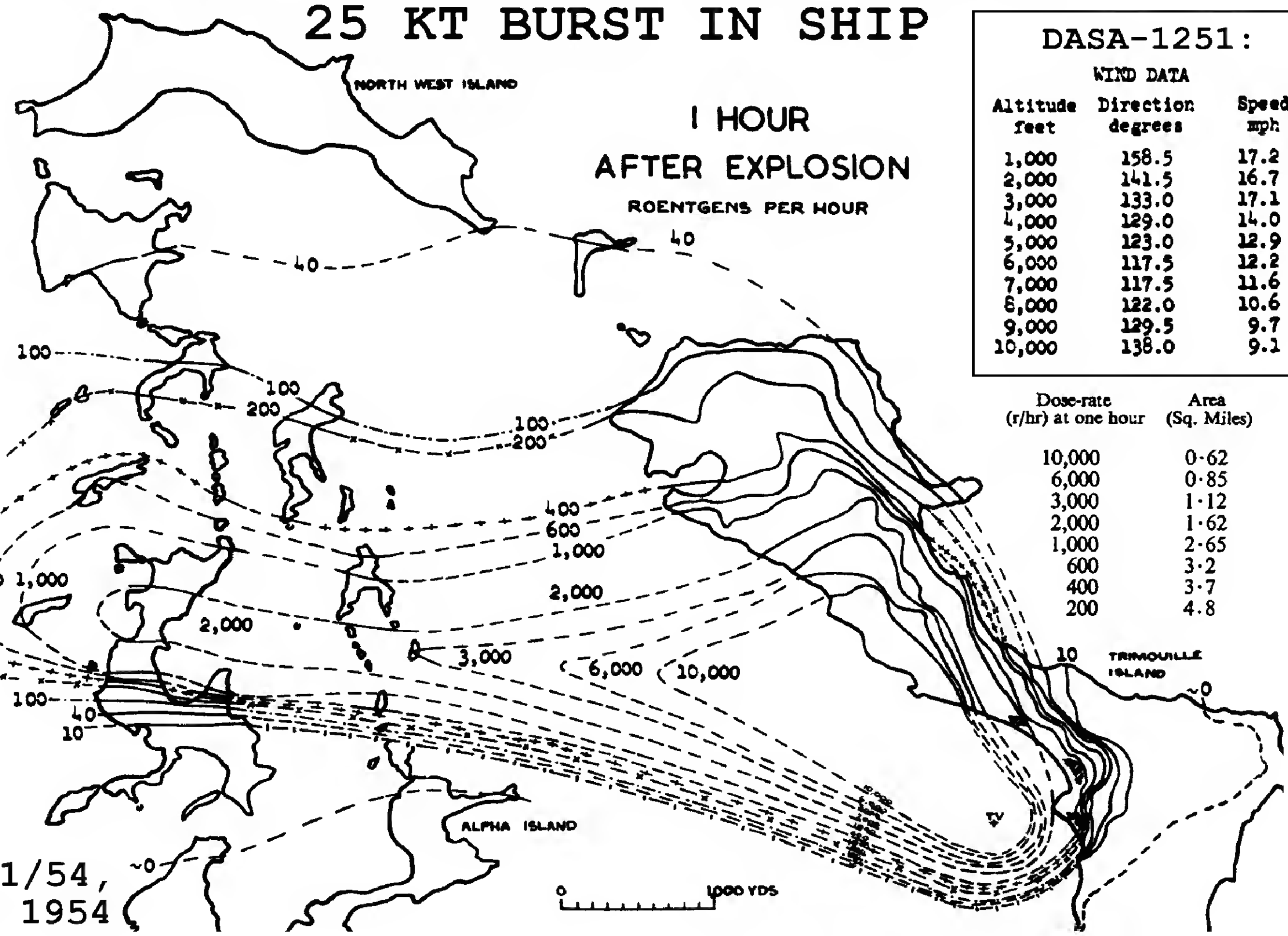


Figure 2.44

OPERATION HURRICANE—THE DOSE-RATE CONTOURS OF THE RESIDUAL RADIOACTIVE CONTAMINATION

25 KT BURST IN SHIP

FIG. 7·2



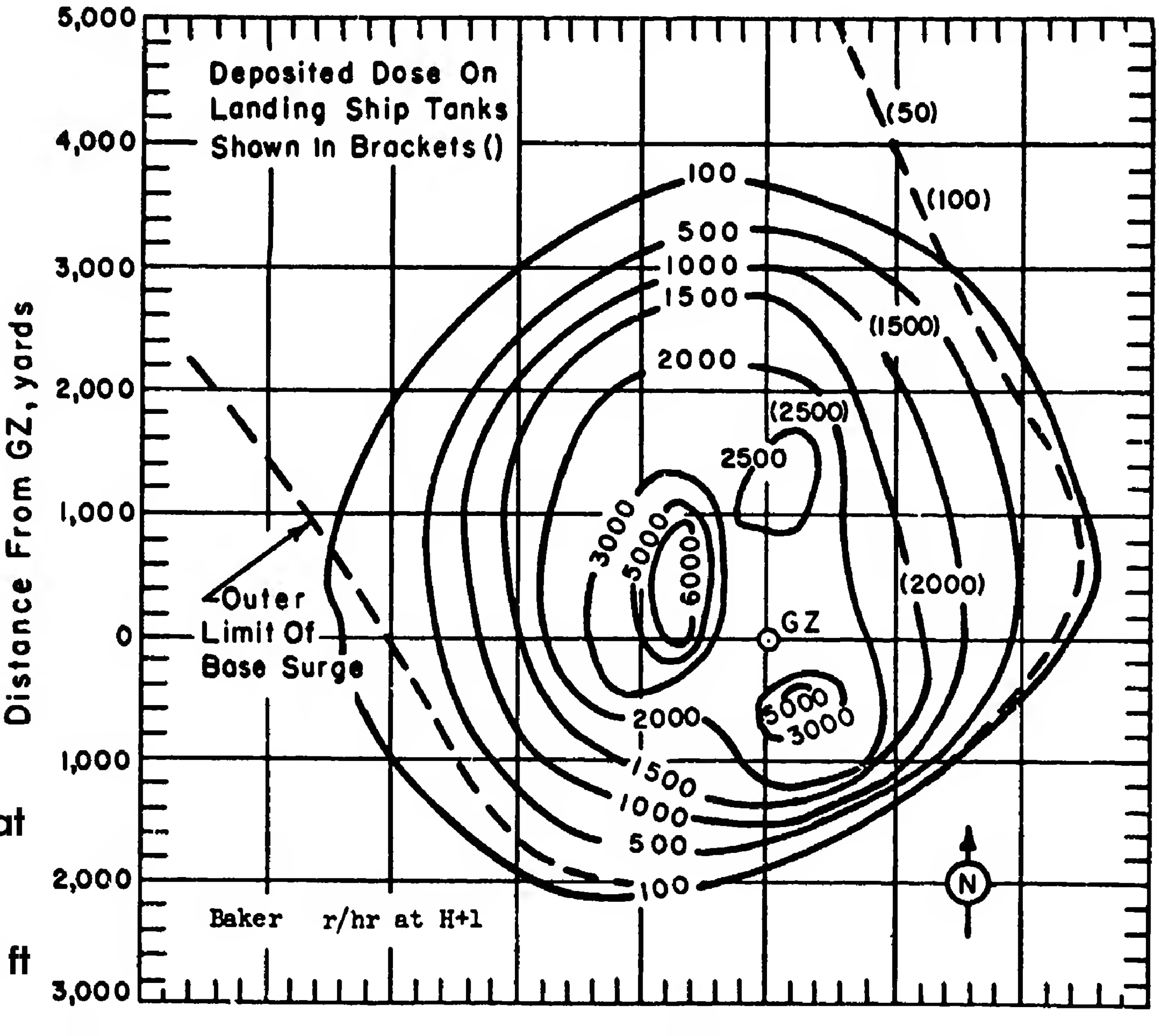
DASA-1251:

WIND DATA

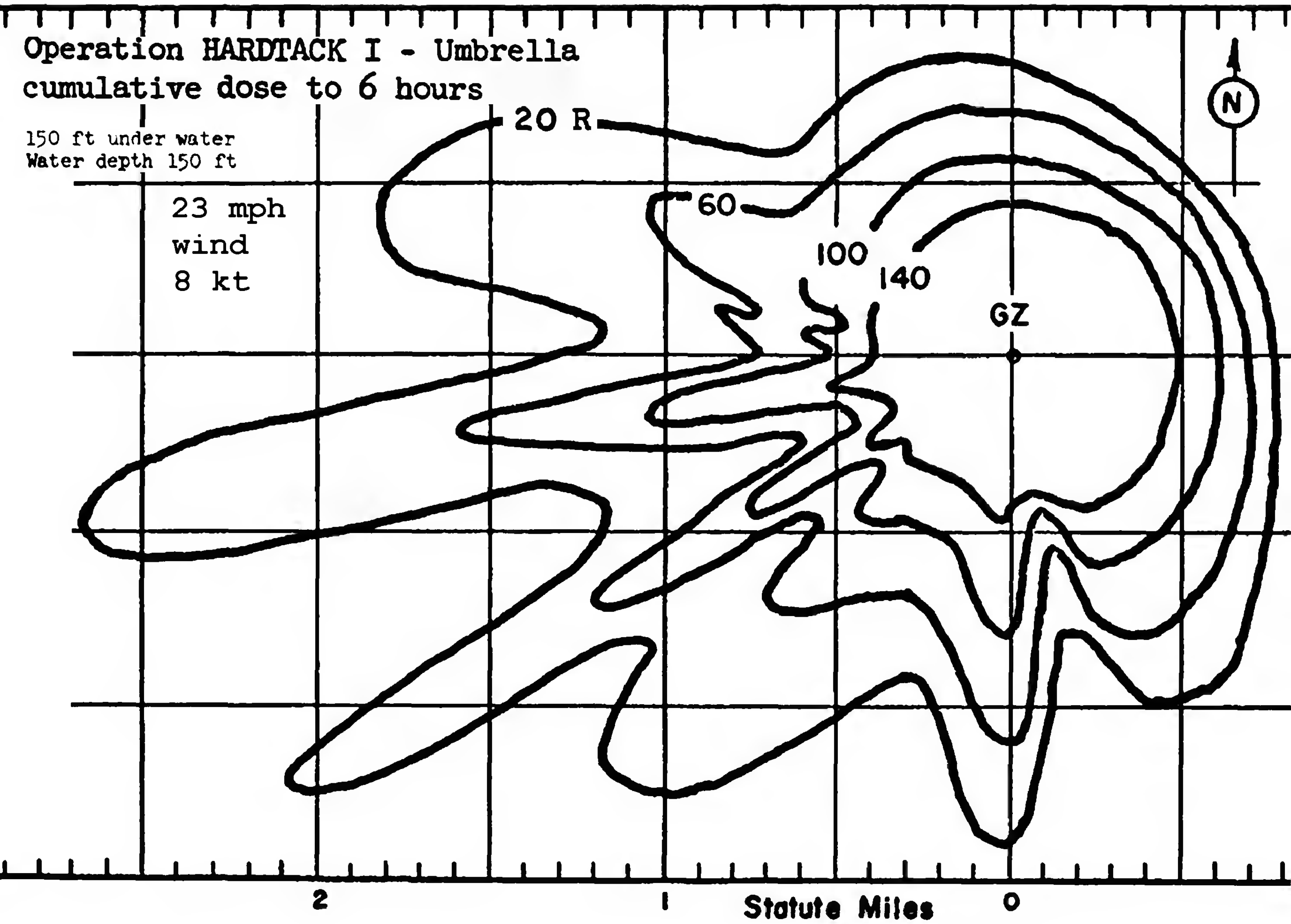
Altitude feet	Direction degrees	Speed mph
1,000	158.5	17.2
2,000	141.5	16.7
3,000	133.0	17.1
4,000	129.0	14.0
5,000	123.0	12.9
6,000	117.5	12.2
7,000	117.5	11.6
8,000	122.0	10.6
9,000	129.5	9.7
10,000	138.0	9.1

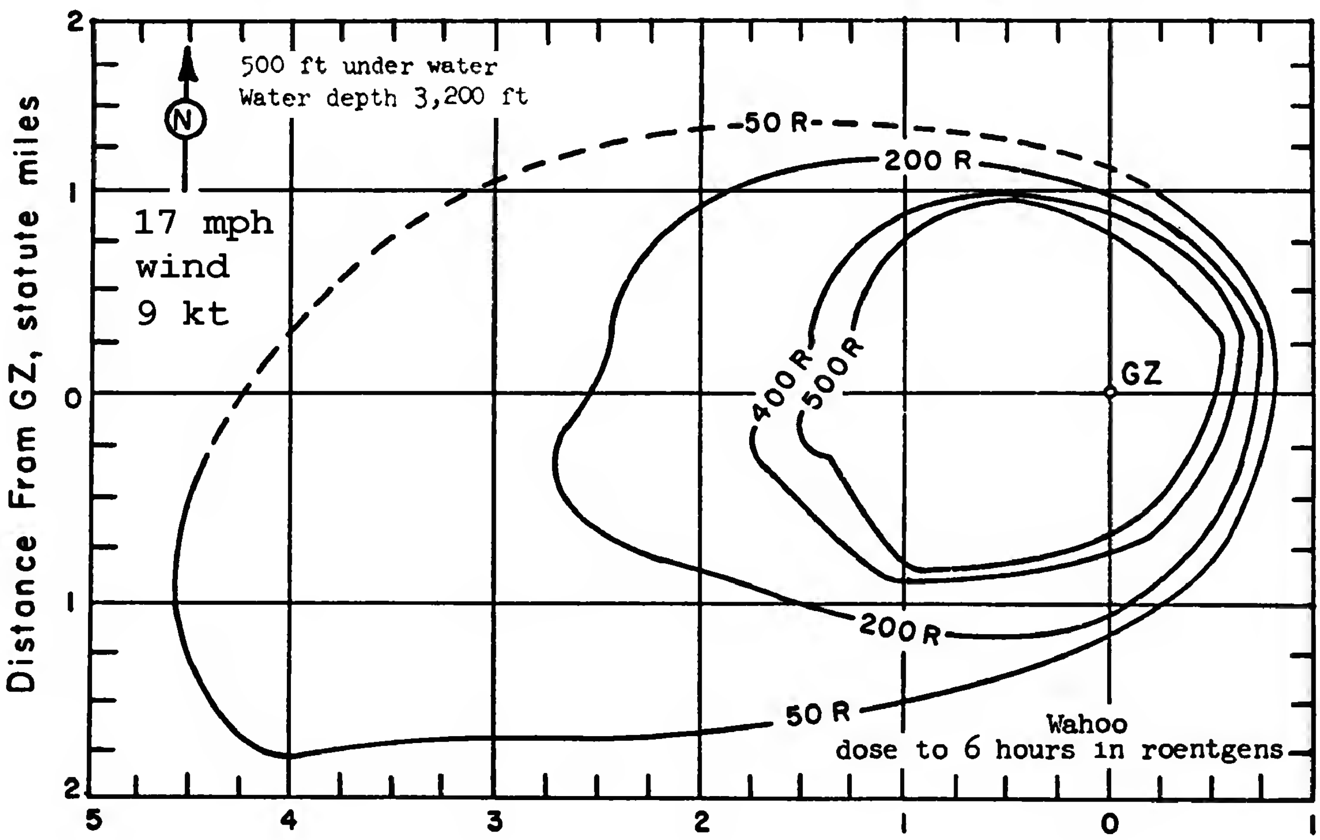
Dose-rate (r/hr) at one hour	Area (Sq. Miles)
10,000	0·62
6,000	0·85
3,000	1·12
2,000	1·62
1,000	2·65
600	3·2
400	3·7
200	4·8

AWRE-T1/54, 27 Aug. 1954

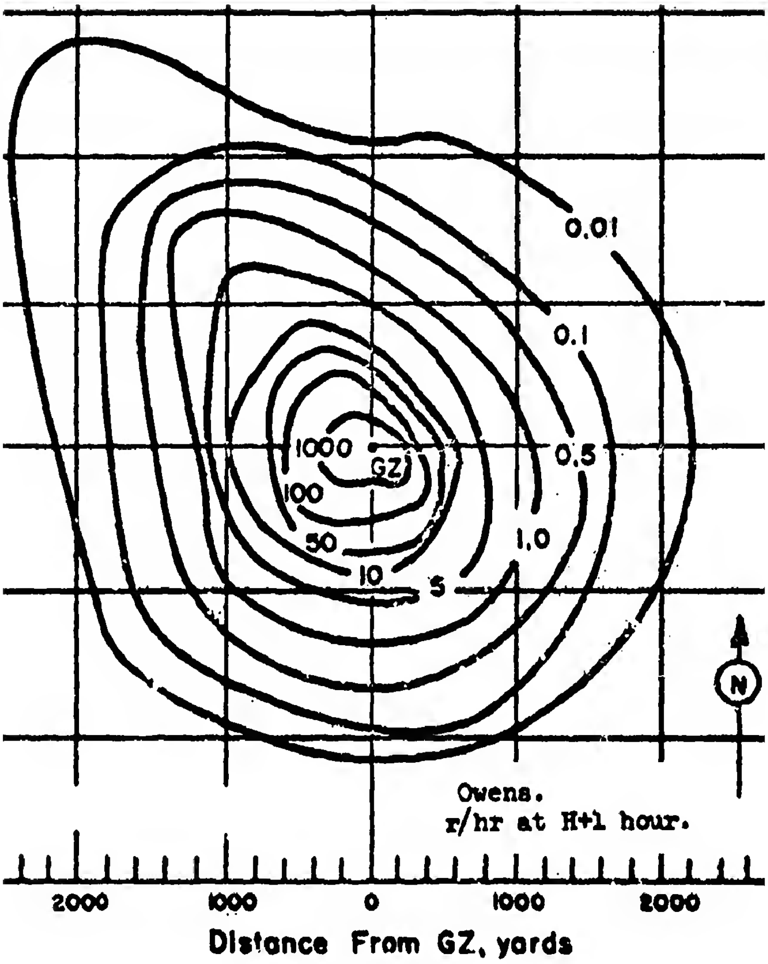


23 kt at 90 ft depth in 180 ft water

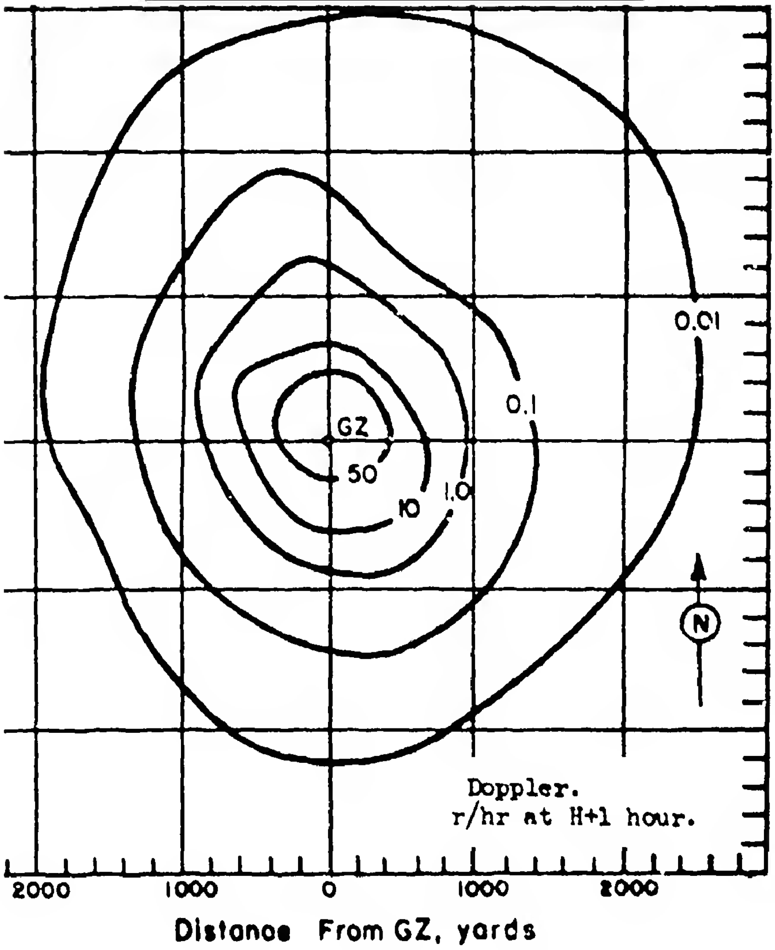

Operation HARDTACK I - Umbrella
cumulative dose to 6 hours
150 ft under water
Water depth 150 ft
23 mph
wind
8 kt
N
20 R
60
100
140
GZ
2
1
Statute Miles
0


500 ft under water
Water depth 3,200 ft
N
17 mph
wind
9 kt
50 R
200 R
400 R
500 R
GZ
200 R
50 R
Wahoo
dose to 6 hours in roentgens
Distance From GZ, statute miles
2
1
0
1
2
5
4
3
2
1
0
1

OWENS 9.7 kt 500 ft balloon air burst



DOPPLER 11 kt 1500 ft balloon air burst



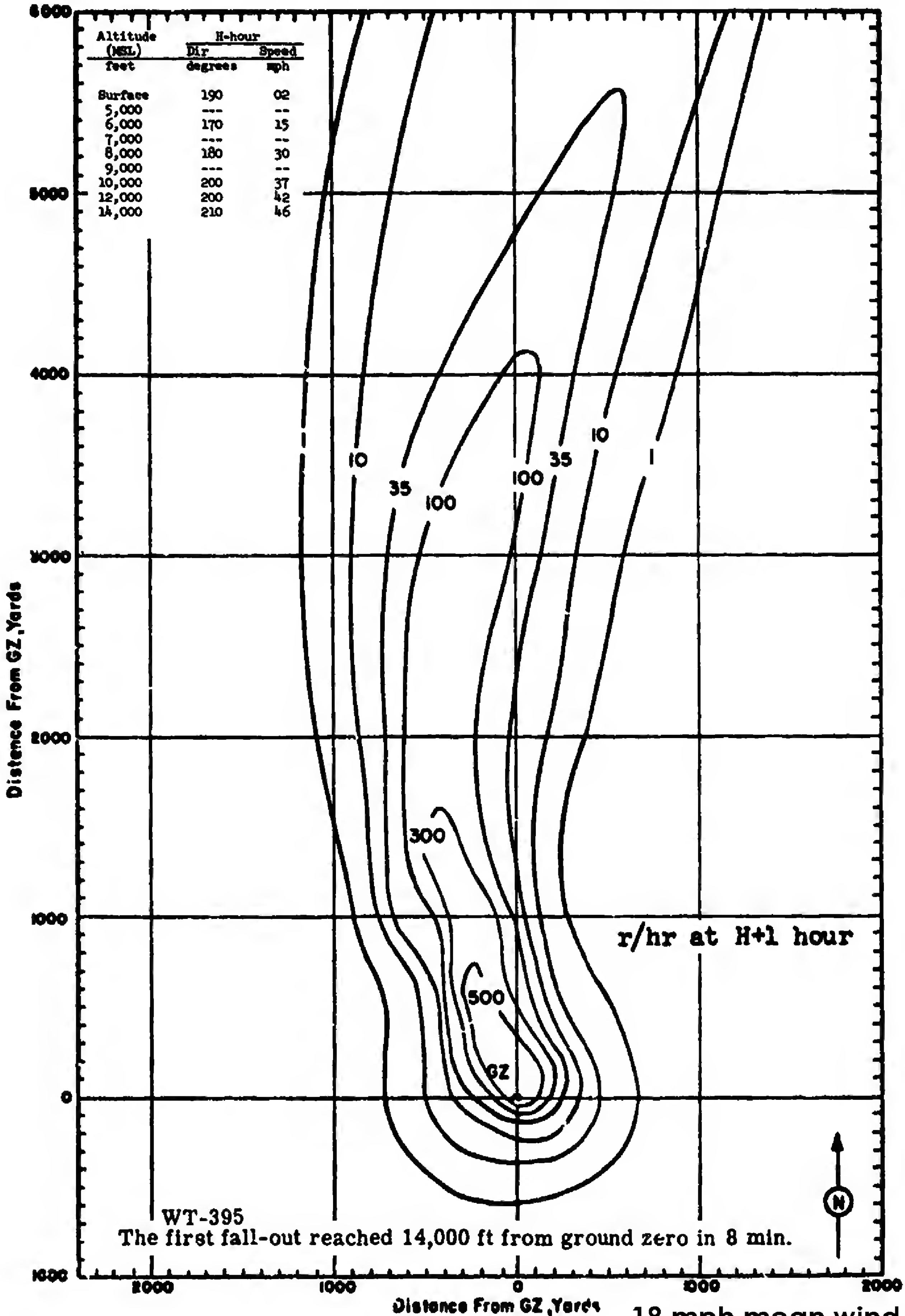
1.2 kt JANGLE - Sugar Surface burst 19 Nov 1951

CLOUD TOP HEIGHT: 15,000 ft MSL

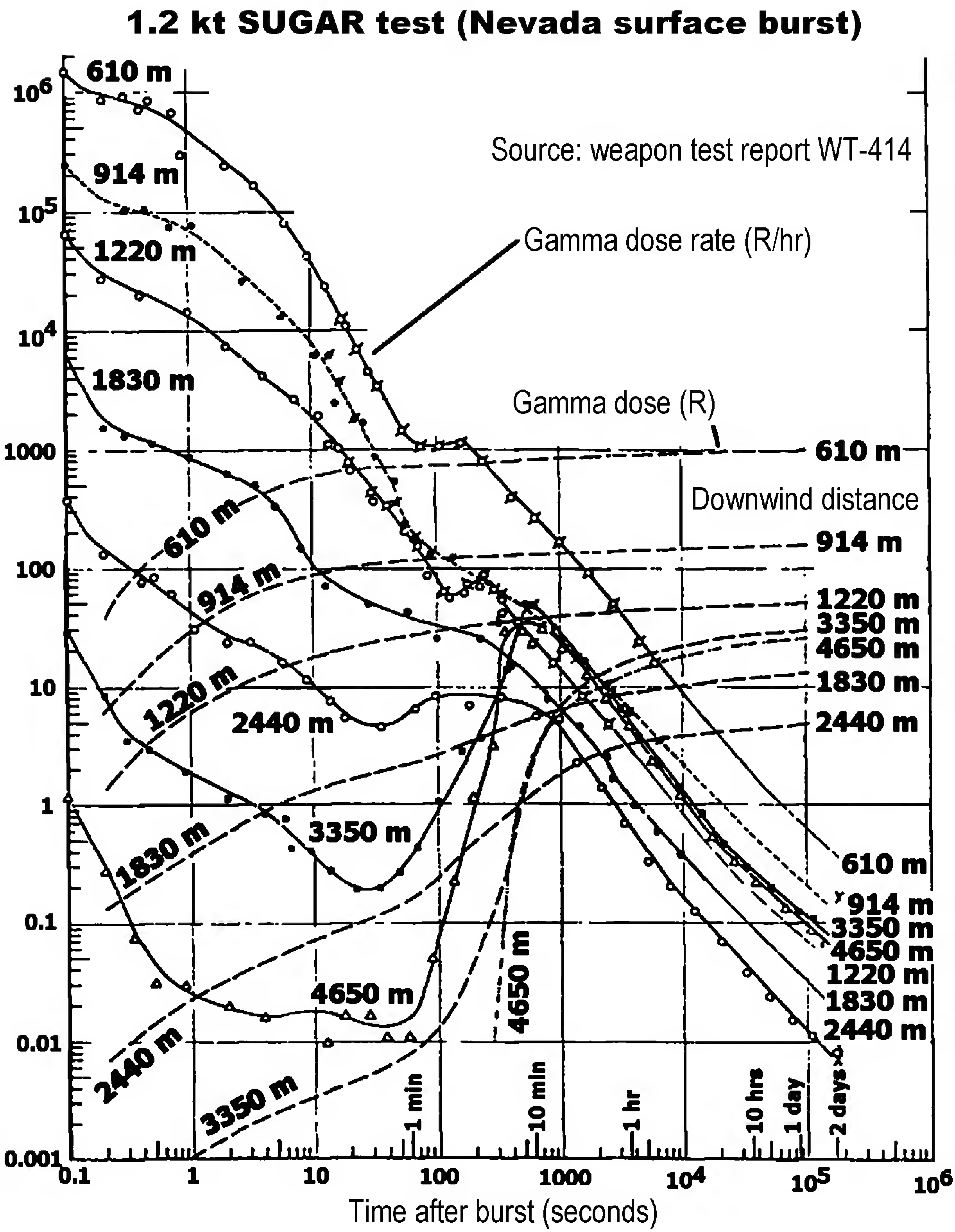
CRATER DATA: Diameter: 90 ft maximum dose rate: 7500 r/hr at H+1 hour
Depth: 21 ft at crater lip

Maximum dose rate		Maximum contour distance from GZ (ft)			Contour area (sq mi)		
Value (r/hr)	Distance from GZ (ft)	500 r/hr	300 r/hr	100 r/hr	500 r/hr	300 r/hr	100 r/hr
540	900	2200	4900	12,500	0.05	0.15	0.55

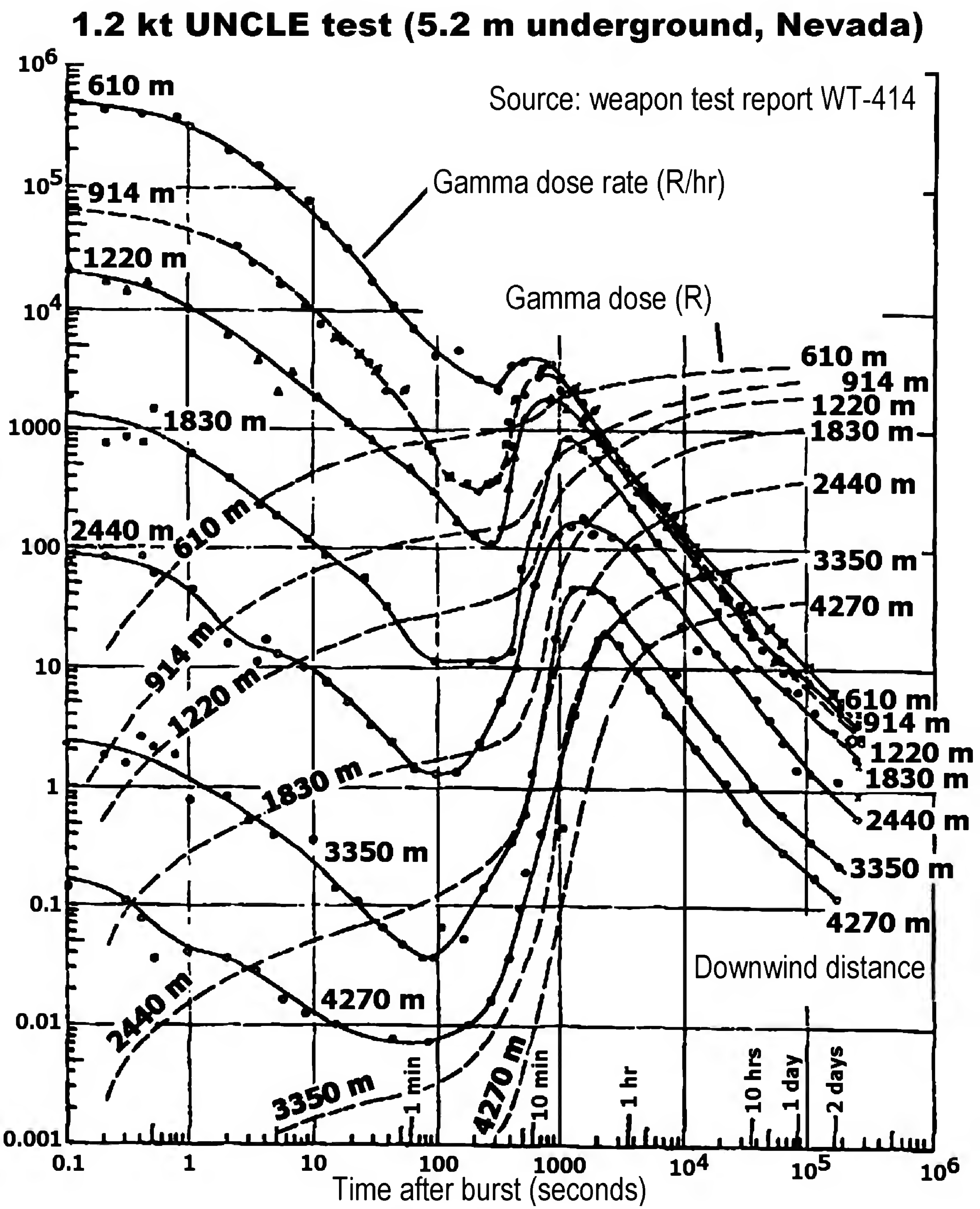
Laurino, R. K., and I. G. Poppoff, 1953: *Contamination patterns at Operation JANGLE.* U. S. Nav. Rad. Def. Lab. Rep. USNRDL-399, 28 pp.



18 mph mean wind speed



1.2 kt SUGAR test (Nevada surface burst)
Source: weapon test report WT-414
Gamma dose rate (R/hr)
Gamma dose (R)
Downwind distance
610 m
914 m
1220 m
1830 m
2440 m
3350 m
4650 m
1 min
10 min
1 hr
10 hrs
1 day
2 days
Time after burst (seconds)



1.2 kt UNCLE test (5.2 m underground, Nevada)
Source: weapon test report WT-414
Gamma dose rate (R/hr)
Gamma dose (R)
610 m
914 m
1220 m
1830 m
2440 m
3350 m
4270 m
Downwind distance
1 min
10 min
1 hr
10 hrs
1 day
2 days
Time after burst (seconds)

43

TIR's indicated, on the average, 0.85 ± 25 percent of the survey meter readings

60

observed/calculated ratio varies from 0.45 at 11.2 hours
to 0.66 from 100 to 200 hours, to 0.56 between 370 and 1,000 hours.

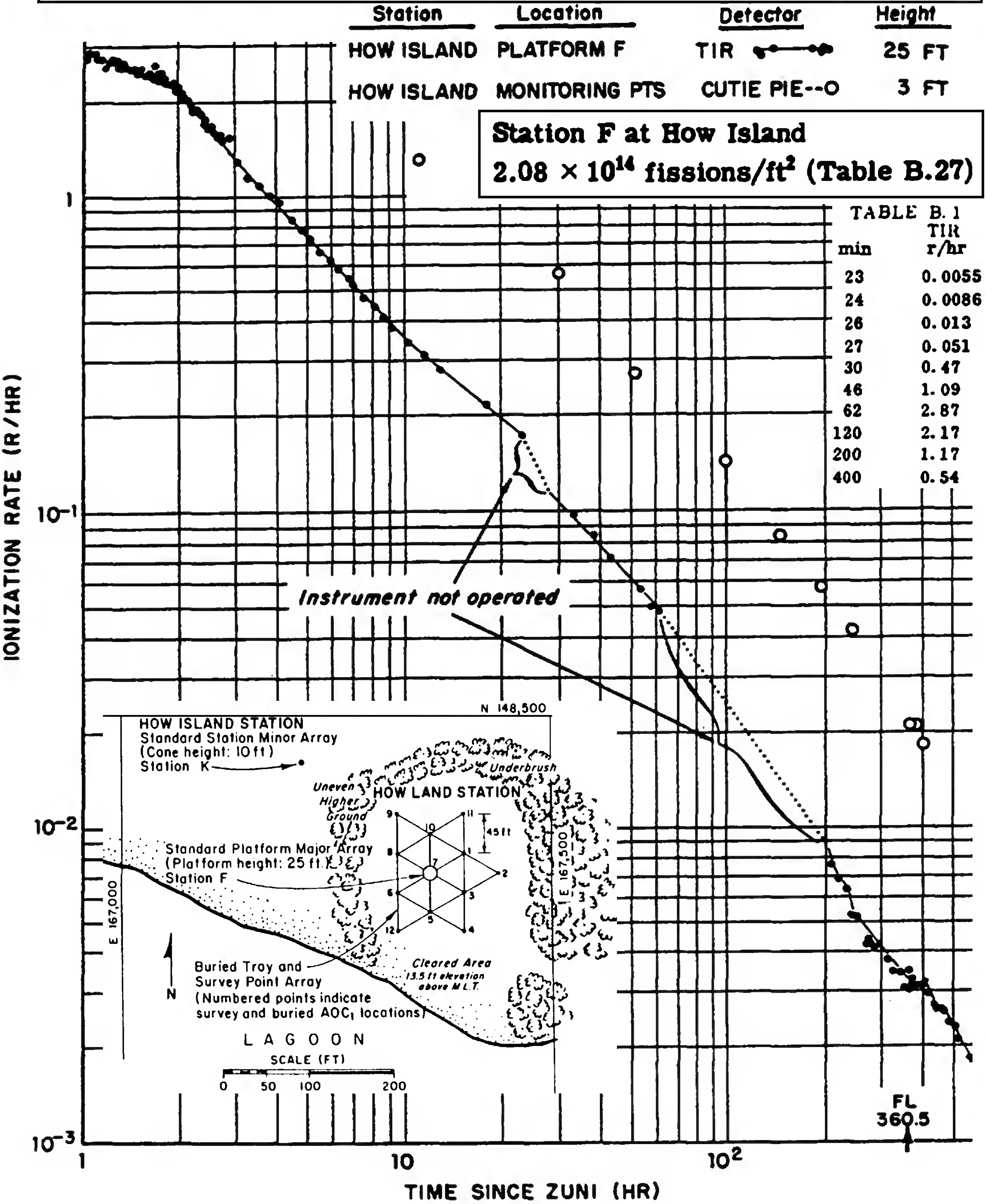
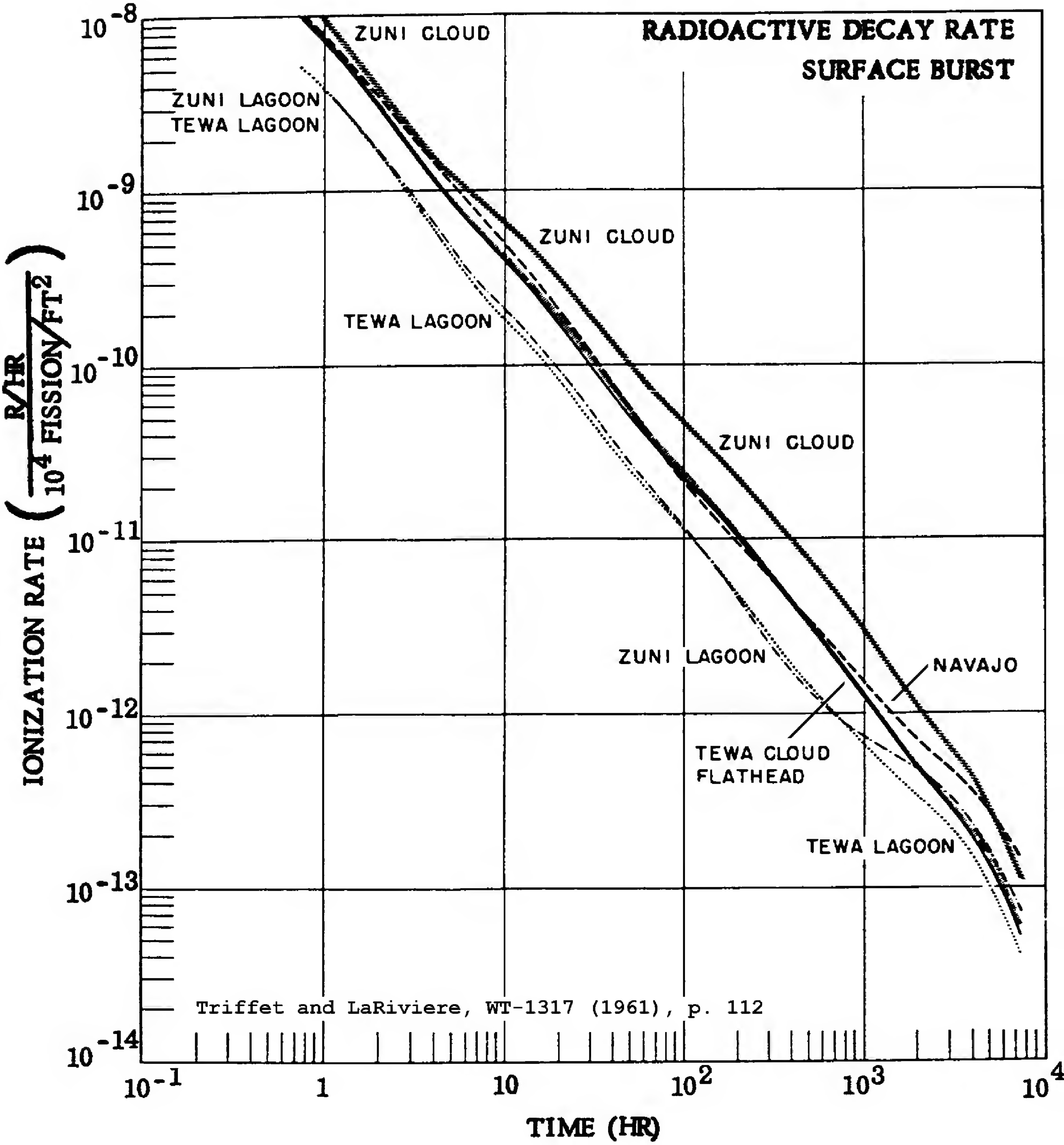


TABLE B.1

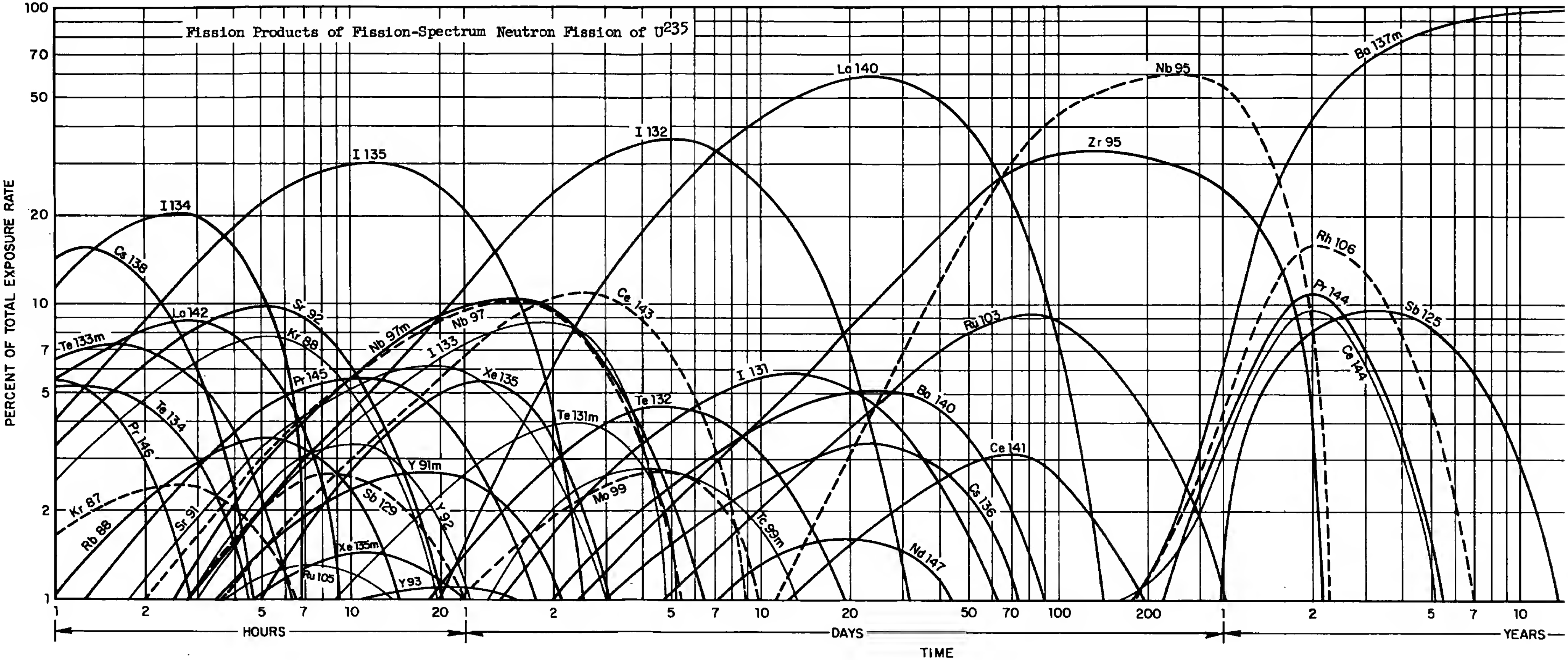
min	TIR r/hr
23	0.0055
24	0.0086
26	0.013
27	0.051
30	0.47
46	1.09
62	2.87
120	2.17
200	1.17
400	0.54

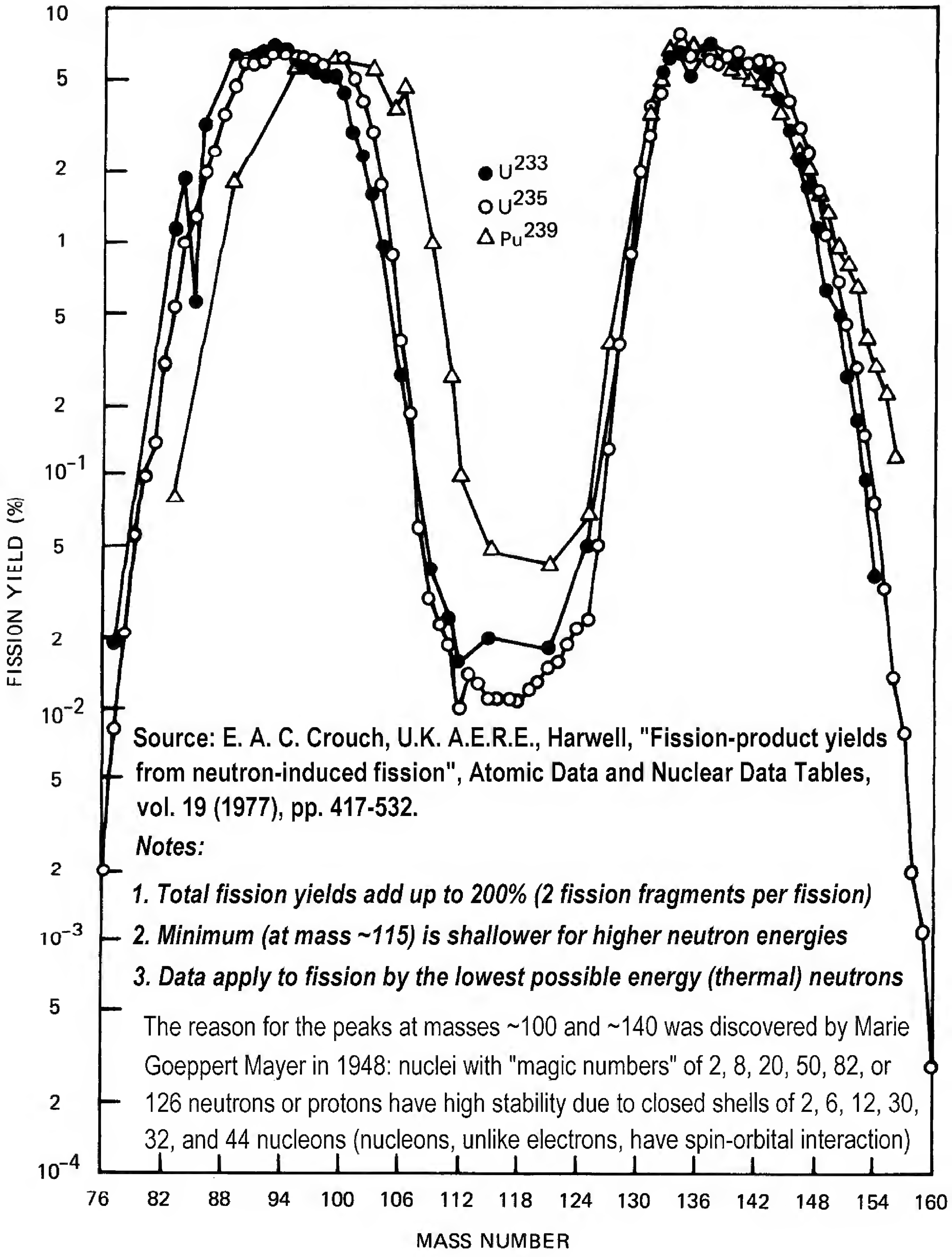
WT-1317

Figure B.7 Gamma-ionization-decay rate, Site How.


RADIOACTIVE DECAY RATE
SURFACE BURST
ZUNI CLOUD
ZUNI LAGOON
TEWA LAGOON
ZUNI CLOUD
TEWA LAGOON
ZUNI CLOUD
ZUNI LAGOON
NAVAJO
TEWA CLOUD
FLATHEAD
TEWA LAGOON
Triffet and LaRiviere, WT-1317 (1961), p. 112
IONIZATION RATE $\left(\frac{R/HR}{10^4\ FISSION/FT^2}\right)$
TIME (HR)
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-1}
1
10
10^2
10^3
10^4

Source: USNRDL-TR-1009 (curves for Pu-239, U-233 and U-238 by different neutron energies are very similar)





Source: E. A. C. Crouch, U.K. A.E.R.E., Harwell, "Fission-product yields from neutron-induced fission", Atomic Data and Nuclear Data Tables, vol. 19 (1977), pp. 417-532.

Notes:

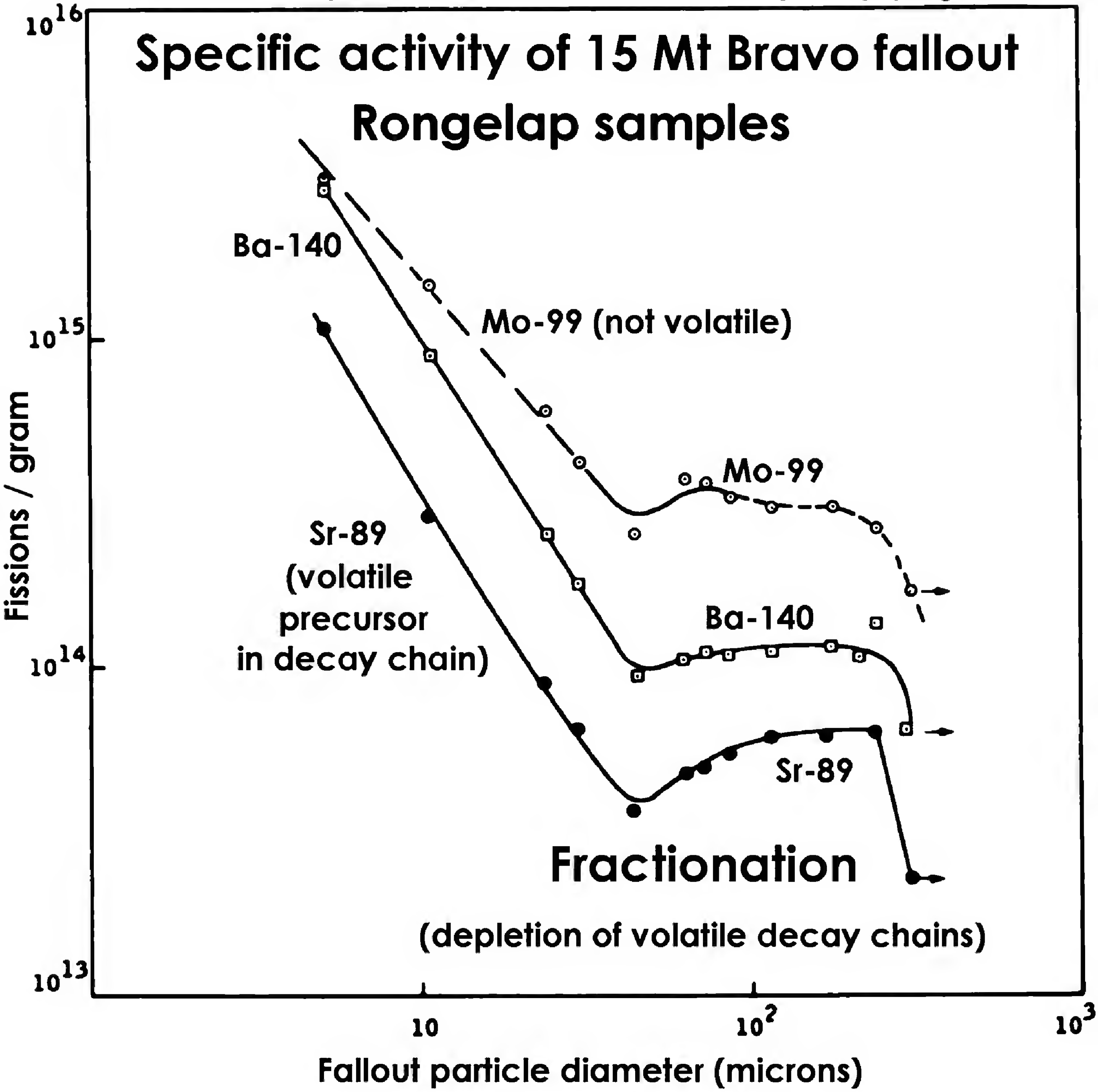
1. Total fission yields add up to 200% (2 fission fragments per fission)

2. Minimum (at mass ~115) is shallower for higher neutron energies

3. Data apply to fission by the lowest possible energy (thermal) neutrons

The reason for the peaks at masses ~100 and ~140 was discovered by Marie Goeppert Mayer in 1948: nuclei with "magic numbers" of 2, 8, 20, 50, 82, or 126 neutrons or protons have high stability due to closed shells of 2, 6, 12, 30, 32, and 44 nucleons (nucleons, unlike electrons, have spin-orbital interaction)

Radioactivity in the Marine Environment (1971), page 13.



Coral Island Surface Explosion (Equivalent fissions $\times 10^{-14}$ per gram)

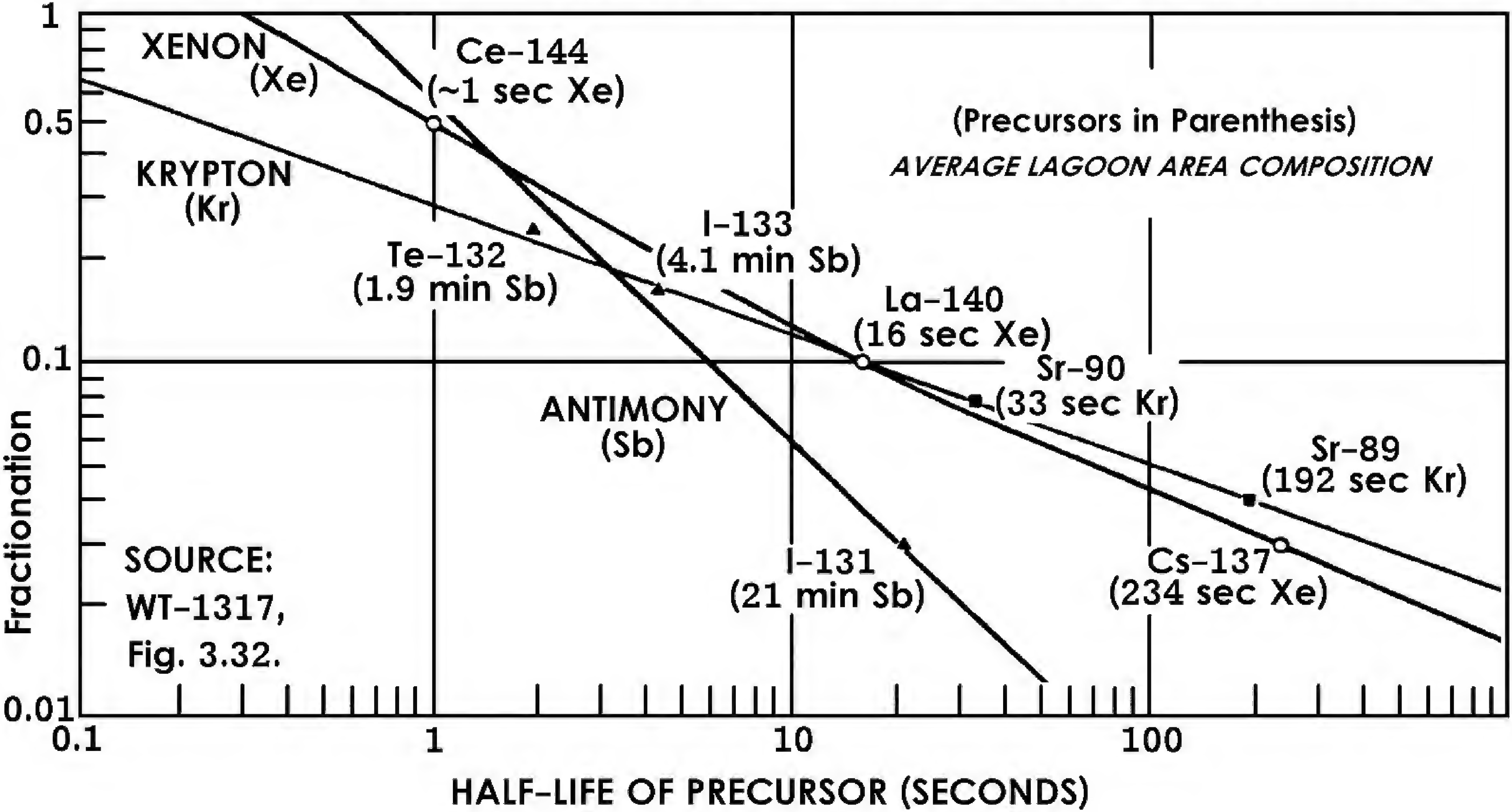
Morgenthau *et al.* (1960). **Weapon Test report WT-1319, "Operation Redwing: Land Fallout Studies"**

REDWING-LACROSSE Normalized to 100% fission yield

0.04 Mt
Shot Atoll **Platform on reef off Runit Island, Enewetak**

$D_g(\mu)$	Chain 99 (^{99}Mo)	Chain 89 (^{89}Sr)	Chain 140 (^{140}Ba)
57	2.5	0.063	0.25
88	4.0	0.074	0.28
125	4.7	0.082	0.30
177	5.7	0.062	0.23
297	4.5	0.044	0.18
594	1.6	0.063	0.24

3.53 Mt coral surface burst REDWING–ZUNI: close–in fallout fractionation factors



Krypton-89, krypton-90, and xenon-140, which are present during the formation of the fireball and are precursors for strontium-89, strontium-90, and barium-140, have very little tendency to be incorporated uniformly in the particles during the early stage of formation. These noble gases, when associated with a particle, are deposited unevenly on the surface layers and distributed along with relatively large deposits of inactive debris which were drawn toward the fireball too late to form fused radioactive particles.

14

Both strontium-89 and strontium-90 are examples of radioisotopes having gaseous precursors and are thus subject to a high degree of fractionation.

$$\text{Krypton-89} \xrightarrow[\text{2.6 min}]{\beta^-} \text{Rubidium-89} \xrightarrow[\text{15 min}]{\beta^-} \text{Strontium-89}$$

$$\text{Krypton-90} \xrightarrow[\text{33 sec}]{\beta^-} \text{Rubidium-90} \xrightarrow[\text{V.Short}]{\beta^-} \text{Strontium-90}$$

31

As expected from the earlier discussion, strontium exhibits very definite fractionation. On one series of air samples collected at 40,000 feet at Operation CASTLE after the Bravo shot, the R value for strontium-89 was 0.35. For a fall-out sample collected on land at approximately 80 miles from the burst point, the R value for strontium-89 was 0.14. The R value for strontium-90 using the same fall-out sample was 0.29.

33

Measured relationship between the fusion yield of the nuclear explosive and the quantity of neutron-induced activities in the fallout*

Test		Redwing-Navajo	Redwing-Zuni	Redwing-Tewa	
Design		Lead pusher	Lead pusher	U-238 pusher	
Total yield		4.5 Mt	3.53 Mt	5.01 Mt	
% Fission		5	15	87	
% Fusion		95	85	13	
Nuclide	*Half life*	*Abundance of nuclide in bomb fallout, atoms per bomb fission*			*R1***
Na-24	15 hours	0.0314	0.0109	0.00284	1284.7
Cr-51	27.2 days	0.0120	0.0017	0.00030	0.280
Mn-54	304 days	0.10	0.011	0.00053	0.614
Mn-56	2.58 hours	0.094		0.00053	2668
Fe-59	45.2 days	0.0033	0.00041	0.00017	6.19
Co-57	272 days	0.00224	0.0031	0.00018	0.113
Co-58	71 days	0.00193	0.0036	0.00029	3.11
Co-60	5.27 years	0.0087	0.00264	0.00081	0.299
Cu-64	12.8 hours	0.0278	0.0090	0.0023	89.5
Sb-122	2.75 days		0.219***		38.4
Sb-124	60 days		0.073***		6.92
Ta-180	8.15 hours	0.038	0.0411		35.9
Ta-182	114 days	0.038	0.0326	0.01	2.67
Pb-203	52 hours	0.0993	0.050	0.000018	26.0
U-237	6.75 days		0.20	0.20	6.50
U-239	23.5 minutes	0.085	0.31	0.36	173
Np-239	56.4 hours	0.085	0.31	0.36	14.9*+*
U-240	14.1 hours		0.005	0.09	0 (no gamma rays)
Np-240	7.3 minutes		0.005	0.09	150

*Dr Terry Triffet and Philip D. LaRiviere, "Characterization of Fallout, Operation Redwing, Project 2.63," U.S. Naval Radiological Defense Laboratory, 1961, report WT-1317, Table B.22. Data on U-238 capture nuclides is from USNRDL-466, Table 6, in combination with WT-1315, Table 4.1.
**Triffet's 1961 values for the gamma dose rate at 1 hour after burst at 3 ft above an infinite, smooth, uniformly contaminated plane, using an ideal measuring instrument with no shielding from the person holding the instrument, from 1 atom/fission of induced activity, (R/hr)/(fission kt/square stat mile).
***The Zuni bomb contained a lot of antimony (Sb), which melts at 903.7K and boils at 1650K. The abundances of Sb-122 and Sb-124 given in the table are for unfractionated cloud samples; because of the low boiling point of antimony, it was fractionated in close-in fallout, so the abundances of both Sb-122 and Sb-124 in the Zuni fallout at Bikini Lagoon were 8.7 times lower than the unfractionated cloud fallout.
*+*Note that Np-239 at 1 hour after burst is still forming as the decay product of U-239.

Measured capture to fission ratios in nuclear tests*

Test shot	*Weapon design*	*Yield*	*Fission %*	*Number of neutron capture atoms per fission*		
				U-239 & Np-239	*U-237*	*U-240 & Np-240*
Jangle-Sugar	U238 reflector	1.2 kt	100	0.59		
Jangle-Uncle	U238 reflector	1.2 kt	100	0.59		
Castle-Bravo	U238 pusher	14.8 Mt	68	0.56	0.10	0.14
Castle-Romeo	U238 pusher	11 Mt	64	0.66	0.10	0.23
Castle-Koon	U238 pusher	110 kt	91	0.72	0.10	
Castle-Union	U238 pusher	6.9 Mt	72	0.44	0.20	0.07
Redwing-Zuni		3.53 Mt	15	0.31	0.20	0.005
Redwing-Tewa		5.01 Mt	87	0.36	0.20	0.09
Diablo	U238 in core**	18 kt	100	0.10		
Shasta	U238 in core**	16 kt	100	0.10		
Coulomb C	U238 in core**	0.6 kt	100	0.03		

* Data is derived from all analyses of aircraft cloud fallout samples and deposited fallout samples in Dr Carl F. Miller, U.S. Naval Radiological Defense Laboratory, report USNRDL-466 (1961), Table 6.

**In these Plumbbob weapon tests, there was no U238 reflector and the only U238 in the bomb was that contained in the fissile core as an impurity.

Spectrum of fission product gamma rays from the thermonuclear neutron fission of U-238 as a function of the degree of fractionation for two different times after detonation (Glenn R. Crocker, *Radiation Properties of Fractionated Fallout; Predictions of Activities, Exposure Rates and Gamma Spectra for Selected Situations,* U.S. Naval Radiological Defense Laboratory, USNRDL-TR-68-134, 27 June 1968, 287 pp.)

Gamma ray energy, MeV	Gamma ray spectrum at 1 hour after burst				Gamma ray spectrum at 1 week after burst			
	Sr-89 abundance (relative to unfractionated fallout)				Sr-89 abundance (relative to unfractionated fallout)			
	10% $R_{89,95} = 0.1$	50% $R_{89,95} = 0.5$	100% $R_{89,95} = 1$*	200% $R_{89,95} = 2$	10% $R_{89,95} = 0.1$	50% $R_{89,95} = 0.5$	100% $R_{89,95} = 1$*	200% $R_{89,95} = 2$
0-0.5	0.396	0.354	0.350	0.304	0.695	0.662	0.678	0.637
0.5-1	0.385	0.379	0.363	0.357	0.262	0.270	0.245	0.265
1-1.5	0.1605	0.1863	0.1914	0.232	0.01339	0.01358	0.01218	0.01273
1.5-2	0.0327	0.0466	0.0558	0.0596	0.0287	0.0519	0.0591	0.0790
2-2.5	0.01628	0.0203	0.0279	0.0290	0.001114	0.001313	0.001268	0.001445
2.5-3	0.00429	0.00717	0.01192	0.01305	0.001372	0.00253	0.00291	0.00388
3-3.5	0.00340	0.00301	0.00267	0.00273	0.0000260	0.0000490	0.0000564	0.0000760
3.5-4	0.001425	0.001187	0.001705	0.00214	0	0	0	0
Total:	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Relative gamma activity	0.547	0.756	1*	1.25	0.563	0.768	1*	1.12
Mean energy, MeV	0.710	0.767	0.807	0.856	0.444	0.486	0.483	0.526

*Unfractionated ($R_{89,95} = 1$) fission product composition relative gamma activity is normalized to 1 unit/second. The presence of neutron induced activities in U-238 like Np-239, U-240, and U-237 due to non-fission capture is not included, and would further soften the fractionated fallout spectra, since they emit low energy gamma rays.

MEAN FALLOUT GAMMA ENERGY FOR LAND BURSTS ZUNI AND TEWA AND AIR BURST CHEROKEE

Terry Triffet and Philip D. LaRiviere, *Characterization of Fallout*, WT 1317 (1961), Table B.21

Test	Mt	Fission	Sample	2 days	3 days	4 days	7 days	10 days	14 days
Aircraft-collected unfractionated cloud samples (no depletion of volatile fission products):									
*Navajo**	4.50	5%	Cloud	0.57	0.48	0.45	0.44	0.53	0.60
Zuni	3.53	15%	Cloud	0.48	0.41	0.42	0.43	0.49	
Tewa	5.01	87%	Cloud		0.40	0.38	0.37	0.46	0.49
*Flathead**	0.365	73%	Cloud			0.34			0.54
Cherokee	3.75	50%	Cloud	0.29	0.30	0.31	0.34	0.42	0.49
*Sea water burst fallout is similar to cloud sample (100 °C droplet condensation prevents fractionation).									
Deposited fractionated land surface burst close-in fallout samples (depletion of volatile fission products):									
Tewa	5.01	87%	YFNB13E56					0.27	0.30
Zuni	3.53	15%	How F-61					0.21	

- Laboratory instrument measurements (ignores degradation due to air scatter of gamma rays). The "clean bombs" *Navajo* and *Zuni* cloud samples include high-energy gamma from sodium-24 (15 hours half life) due to neutron capture by sea salt (NaCl). Low-energy gammas, from Np-239 and U-237 due to neutron capture in U-238, contribute a high proportion of fallout radiation at 4-14 days. Fractionation depletes volatile chains, not Np-239 and U-237, so the mean energy is reduced further.

RADIOACTIVE FALLOUT AND ITS EFFECTS ON MAN pages 1689-1691

A. E. R. E. HP/R 2017

ATOMIC ENERGY RESEARCH ESTABLISHMENT

The Radiological Dose to Persons in the U. K. Due to Debris From Nuclear Test Explosions Prior to January 1956

By N. G. Stewart, R. N. Crooks, and Miss E. M. R. Fisher

Activity from Neutron Capture

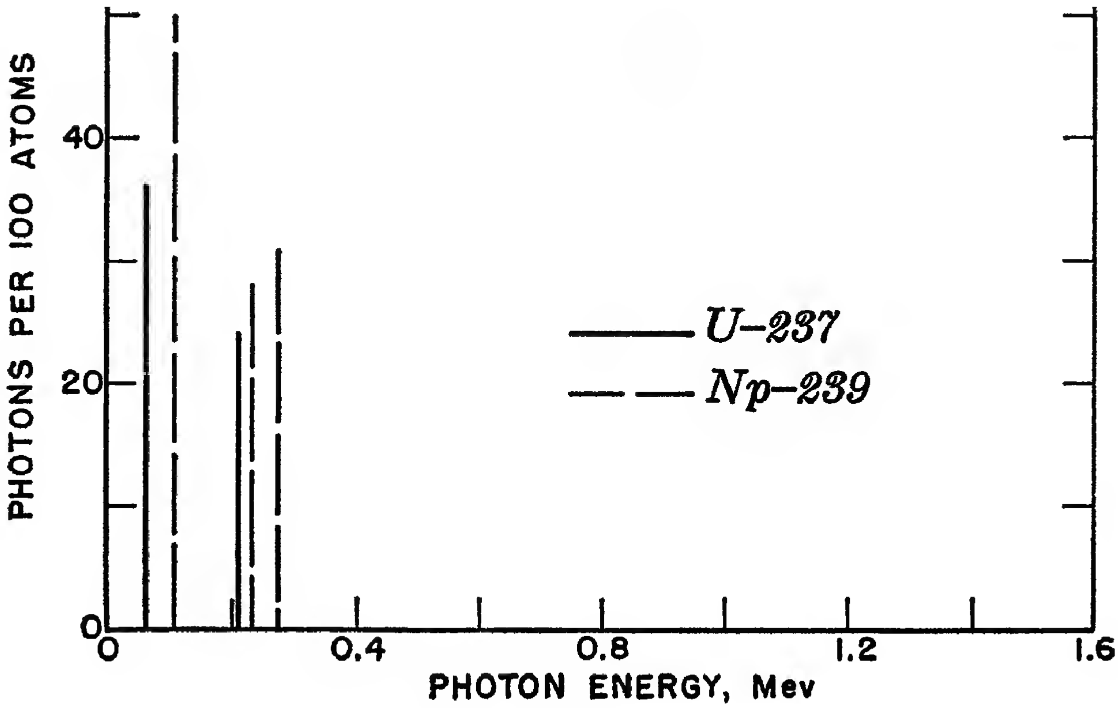
Although several different radioactive elements may be created by the capture of neutrons in materials close to the reacting core of a weapon, the only significant reactions to produce gamma-ray emitters are those associated with the natural uranium which may be used as the tamper material of the bomb.

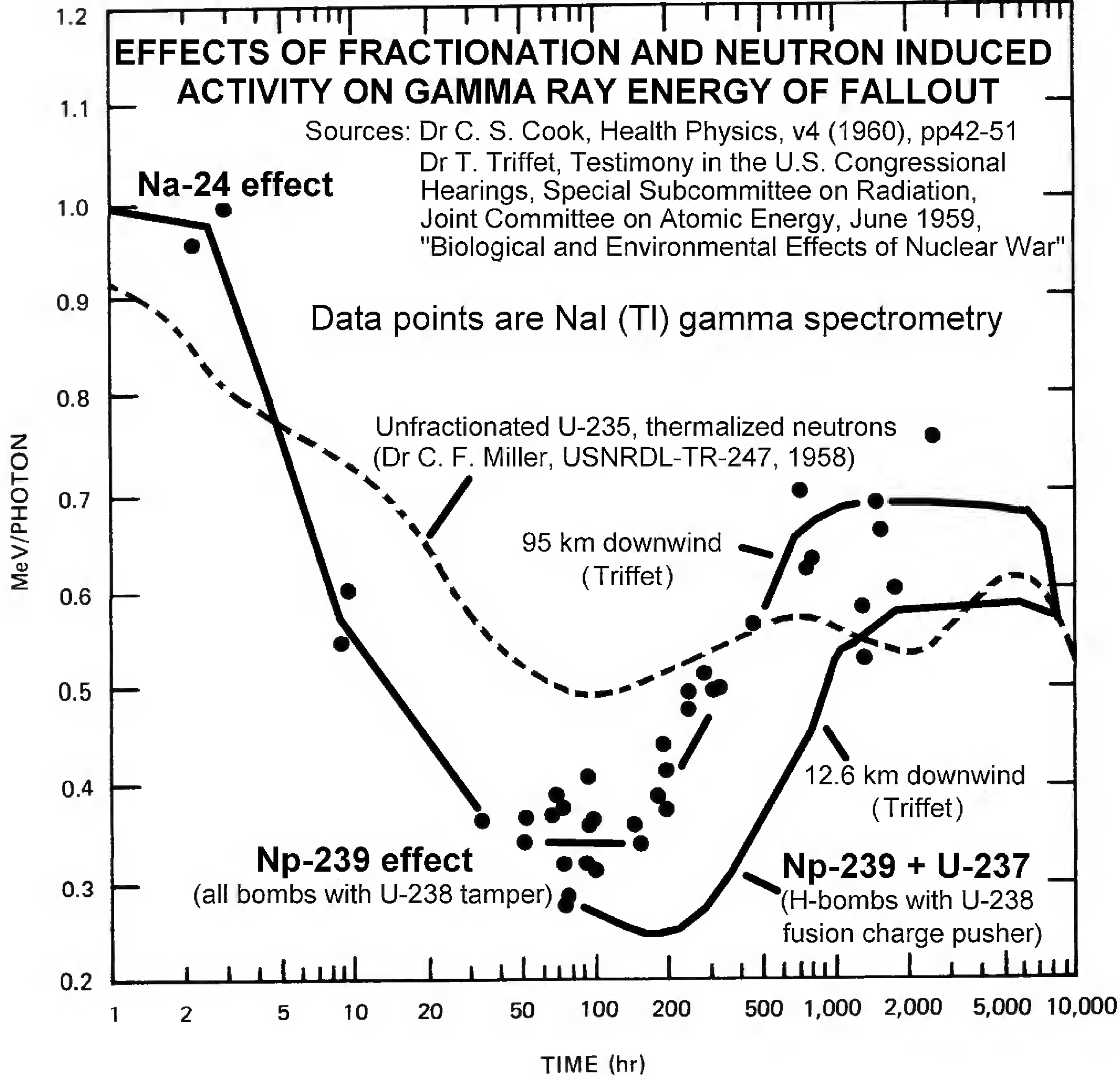
neutron (low energy) + U-238 ⟶ U-239 ⟶ Np-239

Chemical analysis of the debris shows that in general about one neutron is captured in this way for every fission that occurs, both in nominal bombs and in thermonuclear explosions. The U^{239} decays completely before reaching the U.K. but at four days after time of burst the Np^{239} disintegration rate reaches a peak relative to that of the fission products and accounts for about 60% of the observed activity at that time.

In addition to this, a smaller number of the neutrons in a thermonuclear explosion undergo an (n,2n) reaction with U^{238} to form 6.7 day U^{237} which is also a (β, γ) emitter.

neutron (high energy) + U-238 ⟶ 2 neutrons + U-237




EFFECTS OF FRACTIONATION AND NEUTRON INDUCED ACTIVITY ON GAMMA RAY ENERGY OF FALLOUT
Sources: Dr C. S. Cook, Health Physics, v4 (1960), pp42-51
Dr T. Triffet, Testimony in the U.S. Congressional Hearings, Special Subcommittee on Radiation, Joint Committee on Atomic Energy, June 1959, "Biological and Environmental Effects of Nuclear War"
Data points are NaI (TI) gamma spectrometry
Na-24 effect
Unfractionated U-235, thermalized neutrons (Dr C. F. Miller, USNRDL-TR-247, 1958)
95 km downwind (Triffet)
12.6 km downwind (Triffet)
Np-239 effect
(all bombs with U-238 tamper)
Np-239 + U-237
(H-bombs with U-238 fusion charge pusher)
MeV/PHOTON
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1
2
5
10
20
50
100
200
500
1,000
2,000
5,000
10,000
TIME (hr)

BIOLOGICAL AND ENVIRONMENTAL EFFECTS OF NUCLEAR WAR

HEARINGS

BEFORE THE

SPECIAL SUBCOMMITTEE ON RADIATION

OF THE

JOINT COMMITTEE ON ATOMIC ENERGY
CONGRESS OF THE UNITED STATES

EIGHTY-SIXTH CONGRESS

FIRST SESSION

ON

BIOLOGICAL AND ENVIRONMENTAL EFFECTS
OF NUCLEAR WAR

JUNE 22, 23, 24, 25, AND 26, 1959

PART 1

Printed for the use of the Joint Committee on Atomic Energy

UNITED STATES
GOVERNMENT PRINTING OFFICE
43338 WASHINGTON : 1959

RADIATION CHARACTERISTICS OF LAND SURFACE BURST FALLOUT

Average ϒ Energy	8 mi downwind	60 mi downwind
1 hr	--	1.0 mev
2 hr	--	0.95
1/2 day	--	0.60
1 day	--	0.40
1 week	0.25 mev	0.35
1 mo	0.45	0.65

RADIATION CHARACTERISTICS OF WATER SURFACE BURST FALLOUT

Average ϒ Energy	7 mi downwind	22 mi downwind
1 hr	1.0 mev	
2 hr	0.95	
1/2 day	0.60	
1 day	0.40	
1 week	0.35	
1 mo	0.65	

MYRON HAWKINS:

the induced radiation in uranium 238. We can refer to a British report which indicates that around 60 percent of the total activity at 4 days—activity in this case is the number of disintegrations—is due to the uranium 239 and neptunium 239 that are produced, as the British say, in either large or small weapons. I believe part of the hump on the curves in the early times, say around 4 days, is largely due to this.

Dr. TRIFFET. Yes. I thought this might be an appropriate place to comment on the variation of the average energy. It is clear when you think of shielding, because the effectiveness of shielding depends directly on the average energy radiation from the deposited material. As I mentioned, Dr. Cook at our laboratory has done quite a bit of work on this. What it amounts to is that at one hour the average energy is about one Mev. This appears, by the way, in the tables that are in my written statement but that I did not present orally.

Representative HOLIFIELD. Mev. means?

Dr. TRIFFET. Million electron volts. At 2 hours it drops to 0.95. At a half day, to 0.6. At 1 week it drops to 0.35. Then it begins to go up again. At 1 month, it is 0.65, 2 months 0.65. The meaning of this is simply that there is a period around 1 week when if induced products are important in the bomb, there are a lot of radiations emanating from these, but the energy is low so it operates to reduce the average energy in this period and shielding is immensely more effective.

Strontium 90, for example, has 33-second krypton as its birth predecessor; cesium 137 derives from a fission chain headed up by 22-second iodine, followed by 3.9-minute xenon. Because of their volatile or gaseous ancestry in the fireball or bomb cloud a number of the high-yield fission products are formed in finely divided particles. Some of these are so small that they are not subject to gravitational settling, and in fact they remain suspended in the earth's atmosphere for many years, providing[6] that they reach the stratosphere at the proper latitude. In any event such fission products would be depleted in the local fallout.

For example, the irradiation of uranium^{238} with low Mev. neutrons forms neptunium 239, a 2.3-day radioelement which W. J. Heiman[7] estimates might constitute 50 percent of the residual activity a few days after a bomb detonation.

At higher neutron energies, such as certain types of thermonuclear weapons produce, natural uranium undergoes an (n,2n) reaction which competes with fast fission in U^{238}. The data of R. J. Howerton[8] show that U^{238} has a fission cross section of 0.6 barn from 2 to 6 Mev., thereafter climbing to a plateau value of 1 barn for neutrons up to 14 Mev. At 6.6 Mev. there is a threshold for the (n,2n) reaction and the reaction has a cross section of 1.4 barns in the range of 10 Mev. The ready identification of U^{237} in fallout points to fast fission of U^{238} as a main energy source in high-yield megaton-class weapons.

[6] See E. A. Martell, "Atmospheric Circulation and Deposition of Strontium 90 Debris," Air Force Cambridge Research Center paper (July 1958). See also W. F. Libby, "Radioactive Fallout," speech of Mar. 13, 1959.

[7] Variation of Gamma Radiation Rates for Different Elements Following an Underwater Nuclear Detonation," J. Colloid. Science, 13 (1958), p. 329.

[8] "Reaction Cross Sections of U^{238} in the Low Mev. Range," UCRL 5323 (Aug. 15, 1958).

Zuni* fallout gamma ray spectrum measured at 10 days after detonation, 13 miles downwind (sample How F-61 GA)

Gamma ray energy (MeV)	% of gamma rays emitted by fallout sample
0.060	15.5
0.105	38.8
0.220	19.4
0.280	9.3
0.330	3.8
0.500	3.9
0.650	3.1
0.750	6.2
Mean energy	**0.218 MeV**

*W. E. Thompson, *Spectrometric Analysis of Gamma Radiation from Fallout from Operation Redwing,* U. S. Naval Radiological Defense Laboratory technical report USNRDL-TR-146, 29 April 1957, Tables 1 and 2. Note that this is the gamma ray spectrum actually measured for a fallout sample placed near the scintillation crystal of a gamma ray spectrometer, so it does not include the further reduction in gamma ray energy that occurs from Compton scattering in the atmosphere.

SPECTROMETRIC ANALYSIS OF GAMMA RADIATION FROM FALLOUT FROM OPERATION REDWING

Research and Development Technical Report USNRDL-TR-146

29 April 1957

by

W. E. Thompson

Nuclear Radiation Characteristics
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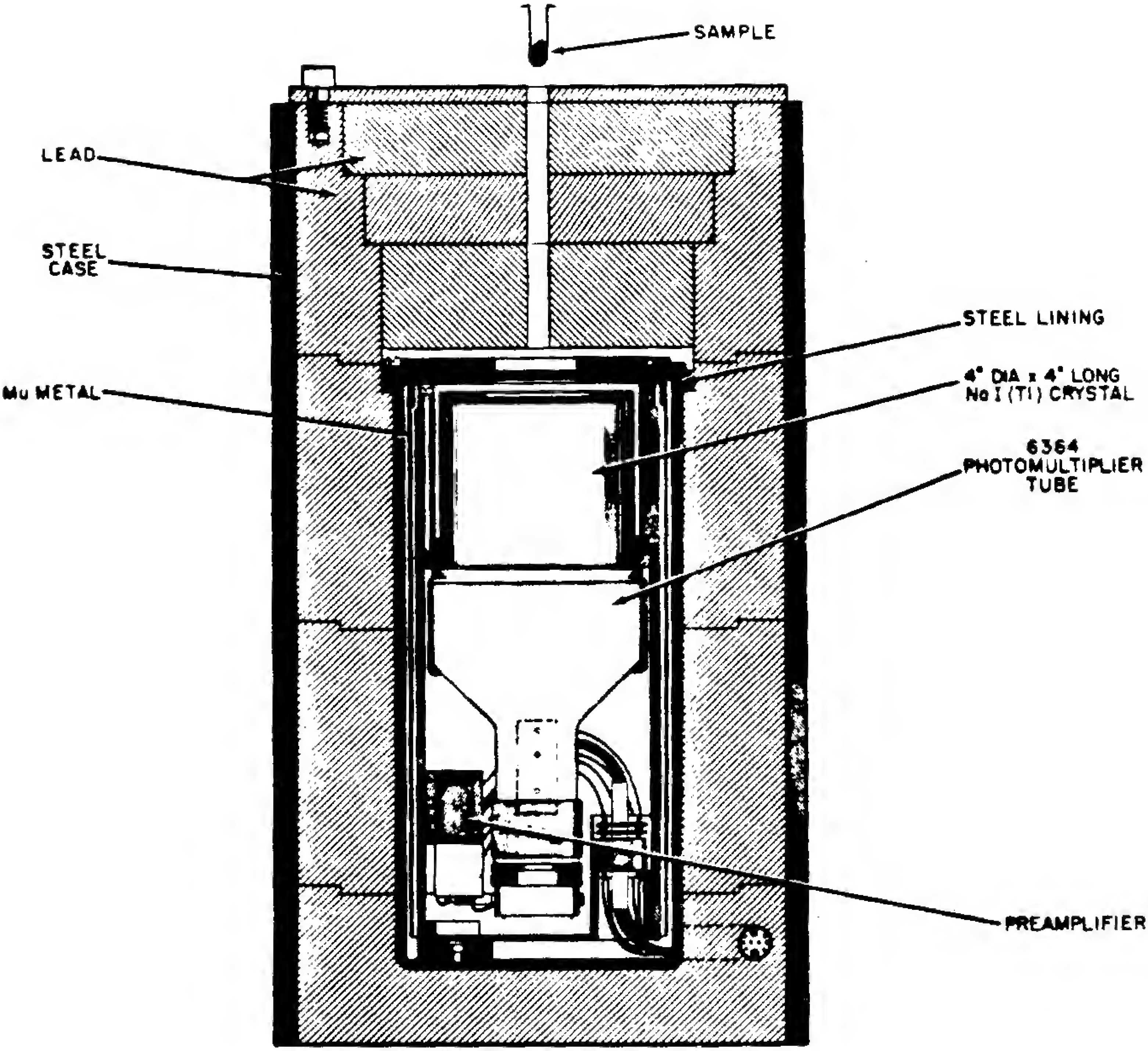
SAMPLE
LEAD
STEEL CASE
STEEL LINING
4" DIA x 4" LONG
Na I (Tl) CRYSTAL
Mu METAL
6364
PHOTOMULTIPLIER
TUBE
PREAMPLIFIER

Fig. 1

TABLE 1

Sample Site Designation	Abbreviated Designation Std Gain	Abbreviated Designation High Gain	Collector Type	Collector Location From GZ
			Shot Cherokee	
Std Cloud	AA	AB	Filter Paper	Cloud
			Shot Zuni	
Std Cloud	BA	BB	Filter Paper	Cloud
YFNB "Whim" 1	FA	–	Deck[(a)]	10 mi ENE
How F-61	GA	GB	OCC[(b)]	13 mi ENE
YAG 40 B-19	HA	HB	OCC	52 NNW
How F-67	IA	IB	OCC	13 mi ENE
YAG 40 B-6	JA	JB	OCC	52 mi NNW
			Shot Flathead	
Std Cloud	KA	KB	Filter Paper	Cloud
YAG 39 C-36	LA	LB	OCC	29 mi NNE
YFNB-13-E-56	MA	MB	OCC	7.5 mi WNW
YFNB-13-E-54	NA	NB	OCC	7.5 mi WNW
			Shot Navaho	
Std Cloud	OA	OB	Filter Paper	Cloud
YFNB-13-E-54	PA	PB	OCC	8.5 mi W
YFNB-13-E-56	RA	RB	OCC	8.5 mi W
YAG 39 C-21	SA	–	OCC	21 mi NNW
YAG 39 C-36	QA	QB	OCC	21 mi NNW
			Shot Tewa	
Std Cloud	TA	TB	Filter Paper	Cloud
YAG 39 C-36	UA	UB	OCC	24 NNW
YFNB-13-E-56	VA	VB	OCC	10 mi SW
Y3-T-1C-D	WA	–	Seawater[(c)]	–
YFNB-13-E-54	XA	XB	OCC	10 mi SW
YAG 39 C-21	YA	YB	OCC	24 mi NNW

(a) Picked up at random from deck of YFNB-29.
(b) Open-close collector
(c) Evaporated sample from large open tank on deck.

Ch

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

TABLE 2

Absolute Photon Intensities (Standard Gain), in Millions of Photons Per Second Per Line for Each Sample

Time After Shot (hr)	Sample and Recording (a)	Line Designation (kev)(b) 60	105	140	220	280	330	370	450	500	570	610	650	750	825	900
53	AA 1	0.75 ± 10(c)	3.32 ± 5	-	1.62 ± 4	1.16 ± 6	0.32 ± 10	-	0.20 ± 20	0.54 ± 10	0.20 ± 20	-	0.92 ± 10	0.88 ± 7	-	0.14 ± 20
74	2	0.60 ± 10	2.70 ± 5	-	1.37 ± 4	0.70 ± 10	0.37 ± 15	-	0.16 ± 20	0.37 ± 10	0.17 ± 20	-	0.77 ± 6	0.62 ± 10	*0.14 ± 30	0.11 ± 20
98	3	0.46 ± 10	1.80 ± 5	-	0.88 ± 6	0.52 ± 10	0.26 ± 10	-	0.12 ± 20	0.30 ± 10	0.08 ± 25	-	0.46 ± 10	0.47 ± 12	-	0.08 ± 40
146	4	0.28 ± 10	1.13 ± 5	-	0.55 ± 6	0.29 ± 12	0.16 ± 12	-	-	0.26 ± 10	-	-	0.29 ± 10	0.28 ± 15	-	-
191	5	0.30 ± 10	0.72 ± 5	-	0.39 ± 10	0.23 ± 10	0.14 ± 15	-	0.09 ± 25	0.20 ± 12	-	-	0.21 ± 15	0.22 ± 15	-	
215	6	0.24 ± 10	0.68 ± 10	-	0.38 ± 10	0.16 ± 10	0.11 ± 15	-	0.06 ± 20	0.20 ± 15	-	-	0.20 ± 15	0.18 ± 20	-	-
242	7	0.24 ± 15	0.58 ± 10	-	0.32 ± 10	0.12 ± 20	0.11 ± 20	-	0.07 ± 30	0.16 ± 20	-	-	0.13 ± 20	0.15 ± 20	-	
262.5	8	0.19 ± 20	0.46 ± 10	-	0.22 ± 10	0.13 ± 25	0.10 ± 25	-	-	0.21 ± 15	-	-	0.10 ± 25	0.13 ± 20	-	
335	9	0.15 ± 15	0.30 ± 10	-	0.14 ± 15	0.06 ± 25	0.07 ± 25		-	0.17 ± 20	-	-	0.05 ± 25	0.08 ± 40	-	
405.5	10	0.10 ± 15	0.19 ± 10	-	0.14 ± 15	0.06 ± 30	0.06 ± 30		-	0.16 ± 25	-	-	0.06 ± 25	0.07 ± 30	-	-
597.5	11	0.05 ± 20	0.07 ± 15	-	0.04 ± 25	0.04 ± 50	0.03 ± 50	-	-	0.09 ± 30	-	-	0.03 ± 50	0.06 ± 40	-	
53	BA 1	>>0	3.71 ± 5	>>0	2.62 ± 5	2.55 ± 7	0.76 ± 10	-	0.46 ± 20	3.32 ± 5	>>0	-	2.57 ± 5	2.05 ± 10	-	0.58 ± 20
69	2	1.20 ± 20	3.11 ± 5	0.83 ± 20	2.17 ± 3	2.04 ± 5	0.83 ± 10	-	0.64 ± 20	2.16 ± 8	>>0	-	1.95 ± 7	1.48 ± 7	-	0.38 ± 20
93	3	0.92 ± 20	2.45 ± 5	>>0	1.71 ± 5	1.51 ± 5	0.54 ± 10	-	0.37 ± 25	1.48 ± 20	0.64 ± 40	-	1.32 ± 10	1.15 ± 10	-	-
117	4	0.80 ± 25	1.85 ± 10	>0	1.32 ± 5	1.06 ± 10	0.52 ± 15	-	0.34 ± 25	1.03 ± 10	>>0	-	0.95 ± 10	0.83 ± 10	-	
192	5	0.48 ± 20	0.99 ± 15	0.28 ± 20	0.74 ± 10	0.43 ± 10	0.43 ± 10	-	0.20 ± 30	0.54 ± 25	0.30 ± 50	-	0.57 ± 10	0.52 ± 20	-	-
242	6	0.32 ± 30	0.65 ± 20	0.28 ± 20	0.46 ± 10	0.26 ± 15	0.32 ± 10	-	0.12 ± 30	0.38 ± 20	0.19 ± 40	-	0.36 ± 15	0.30 ± 15	-	0.09 ± 40
454	7	0.11 ± 20	0.17 ± 20	0.11 ± 35	0.11 ± 20	0.06 ± 25	0.14 ± 20	-	>0	0.25 ± 20	0.13 ± 30	-	0.07 ± 25	0.14 ± 20	*0.08 ± 50	-
790	8	0.04 ± 30	0.05 ± 25	0.08 ± 15	0.05 ± 30	0.02 ± 40	0.01 ± 25	-	0.06 ± 50	0.10 ± 30	0.04 ± 50	-	0.04 ± 40	0.09 ± 20	*0.07 ± 50	-
1295	9	0.02 ± 50	0.02 ± 50	0.05 ± 25	0.02 ± 35	0.02 ± 50	0.03 ± 30	-	>0	0.10 ± 20	-	-	0.06 ± 35	0.07 ± 30	>0	-
240	GA 1	0.20 ± 10	0.50 ± 10		0.25 ± 30	0.12 ± 30	0.05 ± 40	-	-	0.05 ± 30	-	-	0.04 ± 40	0.08 ± 30	-	-
460	2	0.07 ± 20	0.13 ± 20	0.05 ± 20	0.06 ± 20	0.03 ± 30	>0	-	>0	0.03 ± 30	>0	-	-	0.06 ± 28	-	-
266	HA 2	11.44 ± 10	18.10 ± 7	>>0	9.65 ± 10	4.22 ± 15	3.71 ± 15	>>0	>>0	5.52 ± 10	3.60 ± 20	>>0	4.70 ± 10	6.32 ± 10	* >0	0.84 ± 20
362	3	3.35 ± 7	6.81 ± 7	2.78 ± 20	4.56 ± 5	1.51 ± 15	1.76 ± 20	>>0	-	3.38 ± 10	>>0	>>0	2.18 ± 15	3.53 ± 10	* >0	0.76 ± 20
459	4	4.28 ± 10	5.29 ± 10	3.00 ± 20	3.59 ± 5	0.99 ± 25	1.88 ± 20	>>0	>0	3.69 ± 10	1.40 ± 25	1.38 ± 20	1.32 ± 20	3.34 ± 30	* >0	0.67 ± 25
790	5	1.07 ± 15	1.12 ± 10	1.11 ± 10	0.72 ± 10	0.24 ± 20	0.56 ± 20	0.36 ± 30	>0	2.34 ± 15	>>0	0.88 ± 20	0.18 ± 50	2.76 ± 15	* >0	0.21 ± 30
983	6	0.70 ± 15	0.59 ± 15	0.83 ± 10	0.33 ± 15	0.14 ± 30	0.31 ± 25	0.18 ± 30	0.24 ± 30	1.81 ± 17	-	0.81 ± 15	0.32 ± 40	2.90 ± 15	*0.30 ± 50	0.30 ± 20
987	6'	0.54 ± 20	0.57 ± 15	0.89 ± 10	0.33 ± 10	0.15 ± 30	0.31 ± 25	0.17 ± 30	0.24 ± 30	1.82 ± 10	-	0.85 ± 15	0.32 ± 30	2.90 ± 10	*0.29 ± 40	0.29 ± 10
1298	7	0.32 ± 20	0.27 ± 20	0.67 ± 10	0.15 ± 20	0.07 ± 30	0.15 ± 25	0.06 ± 30	0.12 ± 30	1.44 ± 10	-	0.63 ± 10	0.25 ± 30	2.79 ± 10	*0.37 ± 45	0.11 ± 30
1728.5	8	0.30 ± 30	0.19 ± 30	0.47 ± 10	0.14 ± 30	0.10 ± 30	0.06 ± 30	-	0.10 ± 30	0.96 ± 10	-	0.49 ± 10	0.15 ± 30	2.37 ± 10	†0.20 ± 40	0.09 ± 50
2568.5	9	0.22 ± 20	0.11 ± 35	0.23 ± 10	0.08 ± 30	-	-	-	-	0.49 ± 10	-	0.31 ± 15	0.21 ± 35	1.84 ± 10	0.16 ± 40	
2810	10	0.19 ± 20	0.10 ± 50	0.20 ± 20	0.07 ± 40	-			-	0.36 ± 20	-	0.26 ± 15	-	1.66 ± 10	†0.10 ± 40	0.04 ± 50
359	IA 1	0.75 ± 10	1.35 ± 10	0.51 ± 25	0.78 ± 5	0.21 ± 10	0.16 ± 25	0.09 ± 20	-	0.37 ± 10	0.11 ± 25	-	0.10 ± 30	0.41 ± 10	0.10 ± 40	0.54 ± 30
460.5	2	0.52 ± 15	0.87 ± 10	0.27 ± 30	0.52 ± 5	0.09 ± 30	0.09 ± 30	>0	0.05 ± 25	0.30 ± 15	0.10 ± 20	-	0.05 ± 30	0.39 ± 10	0.07 ± 40	0.25 ± 30
981	3	0.10 ± 25	0.10 ± 30	0.04 ± 30	0.05 ± 25	0.03 ± 30	0.02 ± 30	-	>0	0.23 ± 15	0.02 ± 40	0.05 ± 20	-	0.33 ± 10	0.03 ± 40	0.35 ± 40
1606	4	0.06 ± 40	0.02 ± 40	0.05 ± 30	0.04 ± 40	0.03 ± 40	>0		-	0.17 ± 10	-	0.05 ± 35	-	0.35 ± 10	>0	>0
383	JA 1	0.47 ± 20	0.84 ± 15	0.29 ± 30	0.55 ± 10	0.16 ± 20	0.28 ± 10	0.07 ± 25	0.10 ± 30	0.34 ± 15	0.18 ± 20	-	0.21 ± 20	0.46 ± 15	0.22 ± 40	
458	2	0.35 ± 15	0.59 ± 10	0.26 ± 30	0.43 ± 10	0.12 ± 20	0.07 ± 30	-	0.08 ± 30	0.27 ± 20	0.15 ± 30	-	0.17 ± 40	0.41 ± 15	0.14 ± 40	-
982	3	0.08 ± 25	0.08 ± 25	0.12 ± 20	0.05 ± 20	>0	0.04 ± 40	0.02 ± 30	-	0.12 ± 20	>0	0.10 ± 10	0.05 ± 30	0.35 ± 10	>0	-
1605	4	0.05 ± 20	0.04 ± 30	0.07 ± 10	0.03 ± 30	-	0.02 ± 30	-	>0	3.05 ± 30	>0	0.08 ± 20	0.04 ± 40	0.32 ± 15	-	
96.5	KA 2	1.93 ± 30	6.27 ± 10	2.96 ± 30	3.71 ± 10	2.32 ± 15	1.35 ± 20	0.40 ± 35	*0.36 ± 30	1.67 ± 15	0.50 ± 20	-	2.56 ± 5	2.28 ± 10	0.36 ± 30	0.53 ± 20
195	3	0.92 ± 10	2.32 ± 5	0.67 ± 30	1.36 ± 5	0.59 ± 15	0.56 ± 20	>0	*0.16 ± 35	0.76 ± 10	>0	0.17 ± 20	0.79 ± 5	0.92 ± 5	0.28 ± 20	0.23 ± 25
262	4	0.48 ± 10	1.14 ± 5	0.37 ± 30	0.72 ± 5	0.29 ± 15	0.40 ± 10	-	*0.12 ± 30	0.60 ± 10	0.20 ± 25	>0	0.42 ± 5	0.54 ± 5	0.21 ± 30	0.14 ± 25
334	5	0.38 ± 15	0.76 ± 10	0.25 ± 25	0.54 ± 10	0.17 ± 20	0.30 ± 20	-	*0.13 ± 35	0.59 ± 15	0.16 ± 30	-	0.24 ± 15	0.43 ± 10	0.12 ± 40	0.11 ± 35
435	6	0.25 ± 15	0.44 ± 10	0.21 ± 15	0.27 ± 10	0.12 ± 20	0.25 ± 15	-	*0.08 ± 30	0.48 ± 10	0.08 ± 25	-	0.15 ± 15	0.30 ± 10	>0	0.09 ± 30
718	7	0.08 ± 20	0.13 ± 15	0.13 ± 20	0.08 ± 15	0.03 ± 30	0.10 ± 15	-	* >0	0.32 ± 10	0.04 ± 35	-	0.04 ± 25	0.23 ± 10	>0	0.07 ± 40
1031	8	0.03 ± 30	0.04 ± 15	0.07 ± 20	0.03 ± 15	0.01 ± 35	0.04 ± 20	-	*0.02 ± 40	0.16 ± 15	-	-	0.02 ± 30	0.20 ± 15	-	0.03 ± 30
1558	9	0.01 ± 40	0.02 ± 30	0.05 ± 20	0.01 ± 20	-	0.03 ± 40	-	*0.01 ± 50	0.12 ± 15	-	-	0.02 ± 50	0.20 ± 20	-	-
114.5	LA 1	0.66 ± 15	2.18 ± 5	>0	1.20 ± 5	0.79 ± 10	0.38 ± 15	-	*0.12 ± 20	0.39 ± 20	>0	-	0.74 ± 7	0.68 ± 10	>0	-
598	2	0.05 ± 20	0.09 ± 15	0.04 ± 20	0.05 ± 10	0.02 ± 25	0.06 ± 15		*0.01 ± 40	0.10 ± 15	0.02 ± 20	-	0.02 ± 20	0.08 ± 20	0.03 ± 40	-
337	MA 1	0.54 ± 20	0.65 ± 30	>0	0.52 ± 10	0.23 ± 20	0.39 ± 15	-	* >0 0	0.57 ± 10	-	-	0.30 ± 20	0.51 ± 10	>0	
722	2	>0	0.14 ± 20	0.10 ± 20	0.10 ± 15	>0	0.07 ± 30	0.07 ± 20	* >0	0.32 ± 10	>0	-	-	0.30 ± 15	0.07 ± 40	-
1032	3	0.06 ± 20	0.06 ± 20	0.07 ± 20	0.03 ± 20	-	0.35 ± 40		* >0	0.25 ± 15	>0	0.01 ± 35	>0	0.22 ± 20	>0	0.03 ± 30
1538	4	0.01 ± 25	0.02 ± 45	0.03 ± 30	0.02 ± 40	0.01 ± 40	>0	-	*0.02 ± 25	0.10 ± 20	-	-	-	0.14 ± 25	-	0.02 ± 40
357	NA 1	1.07 ± 10	1.64 ± 10	>0	0.56 ± 5	>0	0.14 ± 30		* >0	0.37 ± 15	>0	-	0.20 ± 30	0.41 ± 30	0.09 ± 5	
120	2	0.14 ± 20	0.39 ± 10	0.12 ± 15	0.10 ± 8	>0	0.08 ± 20	-	*0.05 ± 40	0.15 ± 25	0.04 ± 40	-	0.06 ± 40	0.23 ± 25	-	0.06 ± 35
1034.5	3	0.04 ± 40	0.07 ± 30	0.08 ± 25	0.03 ± 25	0.03 ± 30	0.02 ± 50	-	0.04 ± 50	0.09 ± 25	-	-	0.03 ± 50	0.30 ± 15	>0	0.05 ± 40
1538.5	4	0.02 ± 40	0.05 ± 20	>0	0.02 ± 40	-	0.02 ± 50	>0	-	0.06 ± 20	>0	-	0.02 ± 50	0.22 ± 20	0.04 ± 50	0.01 ± 50
51.5	OA 1	0.54 ± 20	0.57 ± 25	0.41 ± 30	0.36 ± 25	0.92 ± 10	0.22 ± 20	>0	* >0 0	0.60 ± 10	-	0.12 ± 35	0.82 ± 10	0.69 ± 10	>0	0.07 ± 30
69	2	0.70 ± 25	0.38 ± 25	0.44 ± 40	0.40 ± 20	0.71 ± 10	0.15 ± 20	-	* >0 0	0.34 ± 15	-	-	0.54 ± 10	0.41 ± 15	>0	0.07 ± 40
141	3	0.39 ± 20	0.22 ± 30	0.14 ± 40	0.19 ± 15	0.26 ± 15	0.09 ± 30	>0	>0	0.11 ± 25	>0	-	0.20 ± 20	0.19 ± 20	-	0.03 ± 35
191	4	0.14 ± 20	0.17 ± 20	0.14 ± 25	0.15 ± 20	0.20 ± 15	>0	-	0.08 ± 25	0.12 ± 20	>0	>0	0.18 ± 20	0.18 ± 20	-	0.06 ± 35
315	5	0.03 ± 30	0.04 ± 30	0.06 ± 30	0.05 ± 30	0.05 ± 30	0.05 ± 30	0.04 ± 30	* >0	0.06 ± 30	>0	-	0.05 ± 25	0.05 ± 30	0.04 ± 35	-
645.5	6	0.03 ± 35	0.05 ± 40	>0	0.01 ± 35	>0	0.02 ± 35	>0	>0	0.02 ± 50	>0	-	-	0.03 ± 50	0.02 ± 50	
197	PA 1	0.19 ± 30	0.47 ± 30	0.24 ± 40	0.32 ± 25	0.20 ± 25	0.23 ± 20	-	*0.11 ± 35	0.33 ± 15	0.10 ± 25	-	0.24 ± 20	0.32 ± 20	0.13 ± 30	
311	3	0.07 ± 25	0.16 ± 30	0.14 ± 40	0.16 ± 30	0.10 ± 30	0.18 ± 25	-	*0.07 ± 40	0.30 ± 15	0.08 ± 20	-	0.12 ± 20	0.19 ± 30	0.15 ± 30	0.06 ± 30
360	4	0.07 ± 35	0.13 ± 35	0.06 ± 35	0.10 ± 30	0.06 ± 40	0.19 ± 35	-	*0.07 ± 40	0.35 ± 25	0.06 ± 30	-	0.09 ± 25	0.21 ± 20	0.17 ± 30	0.08 ± 30
551	5	0.02 ± 40	0.03 ± 40	0.02 ± 40	0.02 ± 40	0.05 ± 40	0.12 ± 20	>0	0.05 ± 40	0.23 ± 15	0.04 ± 35	-	0.03 ± 45	0.12 ± 35	0.12 ± 40	0.06 ± 45
216	QA 1	0.07 ± 30	0.06 ± 30	0.05 ± 35	0.11 ± 10	>0		>0	* >0	0.06 ± 20	>0	-	0.08 ± 30	0.10 ± 30	0.04 ± 40	
360	2	0.02 ± 40	0.03 ± 30	0.02 ± 30	0.03 ± 15	-	0.04 ± 40	-	-	0.04 ± 30	>0	-	0.02 ± 30	0.05 ± 40	0.03 ± 40	
237.5	RA 1	0.08 ± 30	0.14 ± 30	0.11 ± 20	0.14 ± 15	0.13 ± 15	0.05 ± 40	-	*0.02 ± 40	0.14 ± 30	-	-	0.11 ± 15	0.15 ± 15	0.07 ± 40	0.03 ± 40
359	2	0.05 ± 30	0.04 ± 50	0.06 ± 25	0.05 ± 10	0.04 ± 20	0.03 ± 40	-	*0.05 ± 30	0.10 ± 20	-	-	0.05 ± 20	0.08 ± 20	0.05 ± 50	0.02 ± 50
551	3	0.02 ± 40	0.02 ± 50	0.03 ± 40	0.03 ± 25	0.03 ± 25		-	*0.03 ± 50	0.07 ± 30	-	-	0.01 ± 40	0.06 ± 25	0.02 ± 50	-
309.5	SA 1	0.04 ± 30	0.05 ± 25	[illegible] ± 30	0.05 ± 25	0.05 ± 40	>0	0.02 ± 40	0.04 ± 20	0.03 ± 35	-	-	0.04 ± 25	0.06 ± 20	0.04 ± 20	0.02 ± 25
71.5	TA 1	3.48 ± 15	9.81 ± 15	>>0	7.67 ± 5	5.80 ± 5	2.54 ± 10	-	0.98 ± 10	4.55 ± 5	-	1.93 ± 20	5.61 ± 5	4.83 ± 5	>0	0.50 ± 50
93.5	2	2.73 ± 30	9.70 ± 20	>>0	6.27 ± 3	4.18 ± 7	1.86 ± 10	-	*0.80 ± 30	2.77 ± 15	-	0.97 ± 30	4.09 ± 5	3.66 ± 5	>0	>0
137	3	2.48 ± 20	8.50 ± 25	>>0	4.96 ± 5	3.13 ± 10	1.59 ± 15	>0	*3.60 ± 50	2.09 ± 15	-	>0	3.17 ± 10	2.69 ± 5	>0	0.70 ± 50
165	4	1.81 ± 20	6.27 ± 7	2.76 ± 25	3.67 ± 5	2.04 ± 10	1.44 ± 10	-	*0.42 ± 45	1.86 ± 10	-	-	2.26 ± 10	1.99 ± 10	-	0.53 ± 20
240.5	5	1.20 ± 15	3.19 ± 10	0.85 ± 40	1.94 ± 5	0.88 ± 10	0.93 ± 10	-	*0.36 ± 35	1.30 ± 10	* >0	0.36 ± 25	1.03 ± 10	0.94 ± 15	0.65 ± 40	0.36 ± 15
333.5	6	0.66 ± 20	3.47 ± 10	0.56 ± 20	0.91 ± 5	0.36 ± 20	0.65 ± 15	-	* >0	1.03 ± 10	>0	>0	0.50 ± 15	0.73 ± 15	>0	0.20 ± 20
429	7	0.39 ± 30	0.76 ± 15	0.36 ± 30	0.51 ± 10	0.21 ± 30	0.47 ± 20	-	* >0	0.95 ± 10	>0	>0	0.28 ± 25	0.43 ± 25	>0	0.14 ± 30
578.5	8	0.22 ± 30	0.36 ± 20	0.21 ± 20	0.22 ± 25	0.12 ± 25	0.27 ± 20	-	* >0	0.65 ± 15	-	>0	0.09 ± 40	0.37 ± 20	>0	0.11 ± 40
765.5	9	0.12 ± 30	0.20 ± 25	0.19 ± 20	0.09 ± 30	>0	0.16 ± 25	-	* >0	0.59 ± 15	0.06 ± 40	-	0.07 ± 45	0.33 ± 20	0.15 ± 45	0.07 ± 20
1269	10	0.03 ± 35	0.05 ± 30	0.13 ± 30	0.05 ± 35	0.05 ± 50	0.05 ± 30	-	* >0	0.34 ± 15	0.05 ± 30	-	0.06 ± 45	0.30 ± 20	>0	0.03 ± 50
1511	11	0.03 ± 50	0.03 ± 50	0.12 ± 15	0.02 ± 45	>0	0.02 ± 45	-	*0.07 ± 40	0.26 ± 20	0.02 ± 40	-	0.02 ± 50	0.30 ± 20	0.06 ± 45	-
173	UA 1	0.66 ± 15	2.29 ± 10	0.70 ± 30	1.06 ± 5	0.57 ± 20	0.33 ± 25	-	*0.18 ± 40	0.41 ± 10	-	>0	0.67 ± 5	0.61 ± 10	0.29 ± 25	0.09 ± 30
237	2	0.47 ± 20	1.28 ± 20	0.42 ± 50	0.72 ± 10	0.32 ± 15	0.33 ± 25	-	*0.11 ± 40	0.37 ± 25	>0	0.12 ± 40	0.36 ± 15	0.40 ± 15	0.16 ± 45	0.08 ± 30
312	3	0.29 ± 20	0.63 ± 15	0.19 ± 50	0.39 ± 10	0.15 ± 20	0.24 ± 30	-	*0.06 ± 40	0.31 ± 25	-	0.06 ± 50	0.19 ± 20	0.26 ± 25	0.07 ± 50	0.04 ± 35
407	4	0.22 ± 15	0.38 ± 15	0.15 ± 30	0.27 ± 10	0.04 ± 20	0.14 ± 35	-	*0.05 ± 40	0.27 ± 20	-	0.04 ± 50	0.10 ± 30	0.21 ± 20	>0	0.03 ± 45
576	5	0.10 ± 30	0.13 ± 30	0.06 ± 20	0.09 ± 20	0.03 ± 40	0.09 ± 30		0.03 ± 40	0.20 ± 25	0.04 ± 40	0.02 ± 50	0.02 ± 40	0.15 ± 30	0.06 ± 50	
238	VA 1	0.82 ± 10	2.31 ± 10	0.19 ± 35	1.13 ± 5	0.55 ± 15	0.21 ± 30		-	0.39 ± 10		>0	0.33 ± 20	0.50 ± 15	-	0.08 ± 30
335	2	0.49 ± 10	1.11 ± 10	0.22 ± 30	0.55 ± 10	0.20 ± 15	0.16 ± 30		0.09 ± 20	0.29 ± 10	-	-	0.17 ± 30	0.31 ± 15	-	-
413	3	0.32 ± 15	0.58 ± 10	0.14 ± 20	0.35 ± 10	0.09 ± 30	0.07 ± 30		*0.06 ± 40	0.23 ± 15	-	-	0.06 ± 40	0.26 ± 15	>0	-
578	4	0.16 ± 20	0.28 ± 15	0.08 ± 30	0.18 ± 35	0.03 ± 40	0.07 ± 40		0.03 ± 50	0.26 ± 20	-	-	0.05 ± 40	0.24 ± 20	>0	0.04 ± 40
1270	5	0.02 ± 40	0.02 ± 50	0.03 ± 40	0.03 ± 35	0.02 ± 40	0.01 ± 50	-	-	0.11 ± 30	-	>0	0.02 ± 50	0.24 ± 15	-	-
1512	6	0.02 ± 50	0.01 ± 50	0.02 ± 50	>0	0.01 ± 50	>0			0.10 ± 30	-	0.01 ± 50	-	0.17 ± 20	-	-
243	WA 1	0.04 ± 20	0.13 ± 10	0.02 ± 50	0.09 ± 30	[illegible] ± 23	0.02 ± 40		0.02 ± 50	0.03 ± 25	-		0.02 ± 50	0.02 ± 50	0.02 ± 50	-
263	XA 1	0.40 ± 10	1.37 ± 10	0.38 ± 30	0.54 ± 10	0.24 ± 20	0.09 ± 40		*0.03 ± 40	*0.14 ± 25	*0.06 ± 40	>0	0.15 ± 25	0.23 ± 20	0.07 ± 45	0.04 ±
316	2	0.26 ± 15	1.60 ± 10	0.23 ± 30	0.34 ± 10	0.12 ± 25	0.07 ± 30		0.04 ± 30	*0.11 ± 30	*0.06 ± 50	-	0.09 ± 30	0.18 ± 15	-	-
408.5	3	0.18 ± 20	0.36 ± 10	0.10 ± 40	0.24 ± 10	0.05 ± 40	0.05 ± 40	>0	-	*0.10 ± 40	*0.05 ± 40	-	0.07 ± 35	0.15 ± 15	-	-
624	4	0.06 ± 30	0.11 ± 15	0.05 ± 40	0.07 ± 20	0.02 ± 40	0.03 ± 40		* >0	*0.06 ± 50	*0.04 ± 30	-	0.03 ± 50	0.10 ± 20	-	-
287	YA 1	2.36 ± 10	6.10 ± 5	1.90 ± 20	3.59 ± 5	1.37 ± 15	0.82 ± 20		*0.42 ± 30	2.34 ± 10	0.44 ± 30	-	1.68 ± 20	2.36 ± 10	-	0.46 ± 2
411	3	1.34 ± 20	2.56 ± 10	3.83 ± 30	1.52 ± 10	0.45 ± 20	0.60 ± 15	-	*0.24 ± 20	1.83 ± 10	0.24 ± 30	>0	0.66 ± 20	1.61 ± 10	>0	0.27 ± 3
626	4	0.48 ± 10	0.76 ± 15	0.41 ± 20	0.54 ± 10	0.13 ± 40	0.33 ± 10	-	*0.16 ± 30	1.33 ± 10	-	0.06 ± 40	0.12 ± 45	0.96 ± 10	†0.16 ± 40	0.08 ± 5
767	5	0.29 ± 15	0.44 ± 15	0.33 ± 20	0.26 ± 10	0.08 ± 40	0.23 ± 20	-	*0.10 ± 40	1.06 ± 15	>0	>0	>0	0.40 ± 15	>0	0.09 ± 2.
1271	6	0.07 ± 30	0.08 ± 40	0.19 ± 20	0.06 ± 30	0.04 ± 50	0.08 ± 35	-	0.05 ± 30	0.62 ± 15	-	0.08 ± 50	-	0.71 ± 15	>0	0.05 ± 4
1513	7	0.05 ± 40	-	0.17 ± 20	0.07 ± 30	-	0.07 ± 30		-	[illegible] ± 20	-	-	0.07 ± 40	0.81 ± 20		0.03 ±

(a) See Table 1 or explanation of abbreviated designations.

(b) Line designation energy does not necessarily represent an accurate energy calibration. The energy is rounded off to the nearest 10 kev merely as a line identification number.

(c) Errors listed are in percent.

* Indicates an e

TABLE 2

I, in Millions of Photons Per Second Per Line for Each Sample

610	650	750	825	900	960	1040	1100	1170	1240	1370	1600	1690	2750
-	0.92 ± 10	0.88 ± 7	-	0.14 ± 20	-	-	-	-	-	-	0.25 ± 10	-	-
-	0.77 ± 6	0.62 ± 10	*0.14 ± 30	0.11 ± 20	-	-	-	-	-	-	0.25 ± 10	-	-
-	0.46 ± 10	0.47 ± 12	-	0.08 ± 40	-	-	-	-	-	-	0.25 ± 10	-	-
-	0.29 ± 10	0.28 ± 15	-	-	-	-	-	-	-	-	0.27 ± 10	-	-
-	0.21 ± 15	0.22 ± 15	-	-	-	-	-	-	-	-	0.23 ± 15	-	-
-	0.20 ± 15	0.18 ± 20	-	-	-	-	-	-	-	-	0.23 ± 15	-	-
-	0.13 ± 20	0.15 ± 20	-		-	-	-	-	-	-	0.[illegible] ± 10	-	-
-	0.10 ± 25	0.13 ± 20	-		-	-	-	-	-	-	0.21 ± 10	-	-
-	0.05 ± 25	0.08 ± 40	-		-	-	-	-	-	-	0.20 ± 10	-	-
-	0.06 ± 25	0.07 ± 30	-	-	-	-	-	-	-	-	0.15 ± 15	-	-
-	0.03 ± 50	0.06 ± 40	-	-	-	-	-	-	-	-	0.11 ± 20	-	-
-	2.57 ± 5	2.05 ± 10	-	0.58 ± 20	>0	-	-	-	-	0.73 ± 3	0.51 ± 10	-	0.57 ± 10
-	1.95 ± 7	1.48 ± 7	-	0.38 ± 20	0.34 ± 25	0.23 ± 40	-	-	-	0.38 ± 10	0.56 ± 5	-	0.22 ± 20
-	1.32 ± 10	1.15 ± 10	-	-	0.38 ± 20	0.20 ± 40	-	0.27 ± 25	-	0.18 ± 15	0.62 ± 4	-	-
-	0.95 ± 10	0.83 ± 10	-	-	0.24 ± 25	0.18 ± 30	-	0.27 ± 15	-	0.12 ± 25	0.67 ± 5	-	-
-	0.57 ± 10	0.52 ± 20	-	-	-	-	-	-	-	-	0.63 ± 10	-	-
-	0.36 ± 15	0.30 ± 15	-	0.03 ± 40	-	-	-	0.10 ± 30	-	-	0.54 ± 10	-	-
-	0.07 ± 25	0.14 ± 20	*0.08 ± 50	-	-	-	-	-	-	-	0.36 ± 15	-	-
-	0.04 ± 40	0.09 ± 20	*0.07 ± 50	-	-	-	-		-	-	0.17 ± 15	-	-
-	0.06 ± 35	0.07 ± 30	*>0	-	-	-	-	-	-	-	0.06 ± 30	-	-
-	0.04 ± 40	0.08 ± 30	-	-	-	-	-	-	-	-	>0	-	-
-	-	0.06 ± 20	-	-	-	-	-	>0	-	-	-	-	-
>0	4.70 ± 10	6.32 ± 10	*>0	0.84 ± 20	-	-	-	-	-	-	6.88 ± 5	-	-
>0	2.18 ± 15	3.53 ± 10	*>0	0.78 ± 20	-	0.66 ± 25	-	1.10 ± 20	0.59 ± 25	-	3.62 ± 10	0.59 ± 25	-
.38 ± 20	1.32 ± 20	3.39 ± 30	*>0	0.67 ± 20	-	0.50 ± 20	-	0.98 ± 20	>0	-	3.93 ± 10	>0	-
.88 ± 20	0.18 ± 50	2.76 ± 15	*>0	0.21 ± 30	-	-	-	>0	0.59 ± 25	-	1.60 ± 10	0.43 ± 35	-
.81 ± 15	0.32 ± 40	2.90 ± 15	*0.30 ± 50	0.30 ± 20	-	-	-	0.62 ± 30	0.65 ± 25	-	1.36 ± 15	0.48 ± 35	-
.85 ± 15	0.32 ± 30	2.90 ± 10	*0.29 ± 40	0.29 ± 10	-	-	-	0.50 ± 30	0.50 ± 30	-	1.04 ± 15	0.50 ± 30	-
.63 ± 10	0.25 ± 30	2.79 ± 10	*0.87 ± 45	0.11 ± 30	-	-	-	0.50 ± 40	0.56 ± 30	-	0.63 ± 20	0.26 ± 40	-
.49 ± 10	0.15 ± 30	2.37 ± 10	†0.20 ± 40	0.09 ± 50	-	-	-	0.34 ± 40	0.41 ± 20	-	0.32 ± 20	0.26 ± 40	-
.31 ± 15	0.21 ± 35	1.89 ± 10	†0.16 ± 40	-	-	-	-	0.28 ± 40	0.30 ± 30	-	0.16 ± 25	0.07 ± 40	-
.26 ± 15	-	1.66 ± 10	†0.10 ± 40	0.04 ± 50	-	-	-	0.23 ± 40	0.24 ± 40	-	0.07 ± 30	0.13 ± 40	-
-	0.10 ± 30	0.41 ± 10	0.10 ± 40	0.05 ± 30	-	-	-	0.08 ± 40	0.12 ± 25	-	0.15 ± 15	-	-
-	0.05 ± 30	0.39 ± 10	0.07 ± 40	0.05 ± 30	-	-	-	0.08 ± 40	0.12 ± 25	-	0.12 ± 15	-	-
.09 ± 20	-	0.33 ± 10	0.03 ± 40	0.03 ± 40	-	-	-	0.08 ± 40	0.08 ± 30	-	0.03 ± 35	-	-
.05 ± 35	-	0.35 ± 10	>0	>0	-	-	-	0.07 ± 40	0.09 ± 30	-	>0	-	-
-	0.21 ± 20	0.44 ± 15	0.22 ± 40	-	-	-	-	0.15 ± 30	.	-	0.42 ± 10	-	-
-	0.17 ± 40	0.41 ± 15	0.14 ± 40	-	-	-	-	-	-	-	0.36 ± 10	-	-
.18 ± 10	0.05 ± 30	0.35 ± 10	>0	-	-	-	-	-	-	-	0.12 ± 15	0.07 ± 30	-
.08 ± 20	0.04 ± 40	0.32 ± 15	-	-	-	-	-	0.06 ± 40	-	-	0.06 ± 15	0.04 ± 35	-
-	2.56 ± 5	2.28 ± 10	0.36 ± 30	0.53 ± 20	-	-		-	-	-	0.99 ± 8	-	-
.17 ± 20	0.79 ± 5	0.92 ± 5	0.28 ± 20	0.23 ± 25	-	-	-	-	-	-	0.99 ± 3	-	-
>0	0.42 ± 5	0.54 ± 5	0.21 ± 30	0.14 ± 25	-	-	-	-	-	-	0.81 ± 5	-	-
-	0.24 ± 15	0.43 ± 10	0.12 ± 40	0.11 ± 35	-	-	-	-	-	-	0.85 ± 10	-	-
-	0.15 ± 15	0.30 ± 10	>0	0.09 ± 30	-	-	-	-	-	-	0.61 ± 10	-	-
-	0.04 ± 25	0.23 ± 10	>0	0.07 ± 40	-	-	-	-	-	-	0.34 ± 15	-	-
-	0.02 ± 30	0.20 ± 15	-	0.03 ± 30	-	-	-	-	-	-	0.15 ± 15	-	-
-	0.02 ± 50	0.20 ± 20	-	-	-	-	-	-	-	-	0.07 ± 20	-	-
-	0.74 ± 7	0.68 ± 10	>0	-	-	-	-	-	-	-	0.20 ± 15	-	-
-	0.02 ± 20	0.08 ± 20	0.03 ± 40	-	-	-	-	-	-	-	0.08 ± 20	-	-
-	0.30 ± 20	0.51 ± 10	>0	-	-	-	-	-	-	-	0.68 ± 10	-	-
-	-	0.30 ± 15	0.07 ± 40	-	-	-	-	-	-	-	0.32 ± 10	-	-
01 ± 35	>0	0.22 ± 20	>0	0.03 ± 30	-	-	-	-	-	-	0.18 ± 15	-	-
.	-	0.14 ± 25	-	0.02 ± 40	-	-	-	-	-	-	0.0[illegible] ± 30	-	-
-	0.20 ± 30	0.41 ± 30	0.09 ± 5	-	-	-	-	-	-	-	0.68 ± 10	-	
-	0.06 ± 40	0.23 ± 25	-	0.06 ± 35	-	-	-	-	-	-	0.27 ± 15	-	-
-	0.03 ± 50	0.30 ± 15	>0	0.05 ± 40	-	-	-	-	-	-	0.14 ± 20	-	-
-	0.02 ± 50	0.22 ± 20	0.04 ± 50	0.01 ± 50	-	-	-	-	-	-	0.04 ± 30	-	-
-	0.82 ± 10	0.69 ± 10	>0	0.07 ± 30	-	-	-	-	-	0.40 ± 25	0.13 ± 25	.	0.37 ± 20
12 ± 35	0.54 ± 10	0.41 ± 15	>0	0.07 ± 40	-	-	0.05 ± 30	-	-	0.18 ± 25	0.14 ± 20	-	0.16 ± 30
-	0.20 ± 20	0.19 ± 20	-	0.03 ± 35	-	-	>0	-	-	0.04 ± 30	0.15 ± 25	-	-
>0	0.18 ± 20	0.18 ± 20	-	0.06 ± 35	-	-	-	-	-	-	0.19 ± 20	-	-
-	0.05 ± 25	0.05 ± 30	0.04 ± 35	-	-	-	-	-	-	-	0.11 ± 25	-	-
-	-	0.03 ± 50	0.02 ± 50	-	-	-	-	-	-	-	0.04 ± 40	-	-
-	0.24 ± 20	0.32 ± 20	0.13 ± 30	-	-	-	-	-	-	-	0.34 ± 10	-	-
-	0.12 ± 20	0.19 ± 30	0.15 ± 30	0.06 ± 30	-	-	-	-	-	-	0.41 ± 15	-	-
-	0.09 ± 25	0.21 ± 20	0.17 ± 30	0.08 ± 30	-	-	-	-	-	-	0.43 ± 15	-	-
-	0.03 ± 45	0.12 ± 35	0.12 ± 40	0.06 ± 45	-	-	-	-	-	-	0.33 ± 20	-	-
-	0.08 ± 30	0.10 ± 30	0.04 ± 40	-	-	-	-	-	-	-	0.06 ± 30	-	-
-	0.02 ± 30	0.05 ± 40	0.03 ± 40	-	-	-	-	-	-	-	0.03 ± 30	-	-
-	0.11 ± 15	0.15 ± 15	0.07 ± 40	0.03 ± 40	-	-	-	-	-	-	0.1[illegible] ± 20	-	-
-	0.05 ± 20	0.08 ± 20	0.05 ± 50	0.02 ± 50	-	-	-	-	-	-	0.16 ± 25	-	-
-	0.01 ± 40	0.06 ± 25	0.02 ± 50	-	-	-	-	-	-	-	0.09 ± 45	-	-
-	0.04 ± 25	0.06 ± 20	0.04 ± 20	0.02 ± 25	-	-	-	-	-	-	0.09 ± 30	-	-
93 ± 20	5.61 ± 5	4.83 ± 5	>0	0.50 ± 50	1.12 ± 10	-	0.46 ± 20	-	-	-	1.58 ± 10	-	0.09 ± 50
97 ± 30	4.09 ± 5	3.66 ± 5	>0	>0	0.86 ± 10	-	0.39 ± 30	-	-	-	1.60 ± 5	-	-
>0	3.17 ± 10	2.69 ± 5	>0	0.70 ± 50	0.52 ± 20	-	0.29 ± 40	-	-	-	1.72 ± 5	-	-
-	2.26 ± 10	1.99 ± 10	-	0.53 ± 20	>0	-	0.20 ± 45	-	-	-	1.81 ± 3	-	-
36 ± 25	1.03 ± 10	0.94 ± 15	0.65 ± 40	0.36 ± 35	-	-	0.14 ± 40	-	-	-	1.74 ± 5	-	-
>0	0.50 ± 15	0.73 ± 15	>0	0.20 ± 20	-	-	-	-	-	-	1.27 ± 10	-	-
>0	0.28 ± 25	0.63 ± 25	>0	0.14 ± 30	-	-	-	-	-	-	1.06 ± 15	-	-
>0	0.09 ± 40	0.37 ± 20	>0	0.11 ± 40	-	-	-	-	-	-	0.79 ± 20	-	-
-	0.07 ± 45	0.33 ± 20	0.15 ± 45	0.07 ± 20	-	-	-	-	†0.06 ± 40	-	0.52 ± 20	-	-
-	0.06 ± 45	0.30 ± 20	>0	0.03 ± 50	-	-	-	-	-	-	0.19 ± 30	-	-
-	0.02 ± 50	0.30 ± 20	0.06 ± 45	-	-	-	-	-	-	-	0.14 ± 30	-	-
>0	0.67 ± 5	0.61 ± 10	0.29 ± 25	-	0.16 ± 40	-	-	-	-	-	0.27 ± 20	-	-
12 ± 40	0.36 ± 15	0.40 ± 15	0.16 ± 45	0.09 ± 30	-	-	-	-	-	-	0.28 ± 20	-	-
06 ± 50	0.19 ± 20	0.26 ± 25	0.07 ± 50	0.08 ± 30	-	-	-	-	-	-	0.24 ± 15	-	-
04 ± 50	0.10 ± 30	0.21 ± 20	>0	0.04 ± 35	-	-	-	-	-	-	0.21 ± 15	-	-
02 ± 50	0.02 ± 40	0.15 ± 30	0.06 ± 50	0.03 ± 45	-	-	-	-	-	-	0.16 ± 25	-	-
>0	0.33 ± 20	0.50 ± 15	-	0.08 ± 30	-	-	-	-	-	-	0.21 ± 10	-	-
-	0.17 ± 30	0.31 ± 15	-	-	-	-	-	-	-	-	0.17 ± 15	-	-
-	0.06 ± 40	0.26 ± 15	>0	-	-	-	-	-	-	-	0.14 ± 20	-	-
-	0.05 ± 40	0.24 ± 20	>0	0.04 ± 40	-	-	-	-	-	-	0.08 ± 25	-	-
>0	0.02 ± 50	0.24 ± 15	-	-	-	-	-	-	-	-	>0	-	-
01 ± 50	-	0.17 ± 20	-	-	-	-	-	-	-	-	>0	-	-
	0.02 ± 50	0.02 ± 50	0.02 ± 50	-	-	-	-	-	-	-	0.03 ± 25	-	-
>0	0.15 ± 25	0.23 ± 20	0.07 ± 45	0.34 ± 45	-	-	-	-	-	-	0.18 ± 20	-	-
-	0.09 ± 30	0.18 ± 15	-	-	-	-	-	-	-	-	0.16 ± 20	-	-
-	0.07 ± 35	0.15 ± 15	-	-	-	-	-	-	-	-	0.14 ± 25	-	-
-	0.03 ± 50	0.10 ± 20	-	-	-	-	-	-	-	-	0.07 ± 30	-	-
-	1.68 ± 20	2.36 ± 10	-	0.46 ± 25	0.25 ± 30	-	†0.27 ± 15	-	-	-	2.51 ± 5	-	-
>0	0.66 ± 20	1.61 ± 10	>0	0.27 ± 30	-	-	†0.18 ± 25	-	-	-	1.70 ± 5	-	-
6 ± 40	0.12 ± 45	0.96 ± 10	†0.16 ± 40	0.08 ± 50	-	-	†0.08 ± 30	-	*0.14 ± 20	-	1.06 ± 10	-	-
>0	>0	0.90 ± 15	>0	0.09 ± 25	-	-	†0.08 ± 50	-	-	-	0.86 ± 20	-	-
8 ± 50		0.77 ± 15	>0	0.05 ± 40	-	-	†0.04 ± 50	-	*0.08 ± 50	-	0.26 ± 20	-	-
-	0.07 ± 40	0.81 ± 20		0.03 ± 40	-	-	†0.04 ± 50	-	*0.04 ± 40	-	0.16 ± 25	-	-

(c) Errors listed are in percent. * Indicates an energy shift 20-30 kev below line designation. † Indicates an energy shift 20-30 kev above line designation.

PHYSICAL, CHEMICAL, AND RADIOLOGICAL PROPERTIES OF SLURRY PARTICULATE FALLOUT COLLECTED DURING OPERATION REDWING

U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY
San Francisco 24, California

Research and Development Technical Report USNRDL-TR-170

5 May 1957

by

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Table 1 Slurry Fallout Particle Data

Time of Arrival Interval (H+hr)	Ship station	No. of Particles Measured	Average NaCl Mass (μg)	Average H_2O Mass (μg)	Average Density ±Std.Dev. (g/cc)	Average Diameter[a] ±Std.Dev. (μ)
			Flathead			
1 to 3	YFNB-29	4to10	0.06	0.08	1.28±0.1	57±6
7 to 9	YAG-39 & LST-611	50to52	0.42	0.62	1.29±0.01	112±2
11 to 12	YAG-40	10	0.94	1.20	1.35±0.05	129±16
15 to 18	YAG-40	3to4	0.50	0.69	1.34±0.08	121±6
Totals		67 to 76			1.30±0.01	
			Navaho			
1 to 3	YFNB-13	5to20	7.77	7.94	1.38±0.04	272±14
3 to 5	YAG-39	9to14	7.62	4.49	1.50±0.1	229±24
5 to 6	LST-611	14	1.61	1.83	1.41±0.04	166±6
7 to 9	YAG-40	4to10	1.25	1.08	1.45±0.04	142±22
9 to 10	YAG-40	5to23	0.44	0.60	1.31±0.02	110±5
10 to 11	YAG-40	11to15	0.66	0.50	1.43±0.03	111±4
11 to 12	YAG-40	33	0.30	0.44	1.32±0.01	94±4
12 to 13	YAG-40	28	0.31	0.31	1.37±0.01	96±2
13 to 14	YAG-40	6	0.17	0.27	1.28±0.02	86±7
14 to 15	YAG-40	5	0.10	0.18	1.30±0.03	75±2
15 to 18	YAG-40	13to14	0.06	0.32	1.15±0.02	84±4
Totals		133 to 182			1.35±0.01	

(a) The diameter of the spherical slurry droplet at the time of arrival

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RADIOCHEMICAL ANALYSIS OF INDIVIDUAL FALLOUT PARTICLES

Research and Development Technical Report USNRDL-TR-386

17 September 1958

by

J. L. Mackin
P.E. Zigman
D.L. Love
D. MacDonald
D. Sam

DEPARTMENT OF THE NAVY · NAVAL RADIOLOGICAL DEFENSE LABORATORY

U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY

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TABLE 2 (ZUNI, barge YFNB-29; see Table B8 in WT-1317)

Weight, Activity, and Fission Values for the Sized Fractions From the WHIM Sample (YFNB29, 17 km from ZUNI)

Size Range (μ)	Weight: Grams	Weight: Percent of Total	Fissions: Percent of Total	Fissions: Total (10^{14})	Fissions: Per Gram (10^{14})
>1000	37.70	41.8	15.8	21.	0.56
500-1000	41.91	46.4	46.0	60.	1.4
250- 500	4.97	5.5	19.8	26.	5.2
100- 250	3.51	3.9	10.7	14.	4.0
50- 100	0.80	0.9	2.3	3.0	3.8
<50	1.38	1.5	5.4	7.1	5.1
Total	90.27			131.	1.5

TABLE 4 (ZUNI: BIKINI/HOW ISLAND, YFNB29, YAG40; TABLE 3.9 IN WT-1317)

Mean Values for Several Quantities, for Altered and Unaltered Particles

Quantity	Melted coral sand — Altered: No. of Samples	Melted coral sand — Altered: Value	Unmelted coral sand — Unaltered: No. of Samples	Unmelted coral sand — Unaltered: Value
fiss/gm($\times 10^{14}$)	6	3.8 ± 3.1	9	0.090 ± 0.12
Ba^{140}-R value	5	0.090 ± 0.068	8	2.1 ± 1.2
Sr^{89}-R value	7	0.018 ± 0.010	10	0.65 ± 0.17

The data of Table 4 show that the value of fissions/gram was much larger in the altered particles than in the unaltered particles. The R value data indicates that the altered particles were markedly depleted in Ba^{140}-La^{140}, whereas the unaltered particles were enriched in Ba^{140}-La^{140}

R values

With respect to fractionation of radionuclides it has long been accepted that the mass 89 and mass 140 chains which exist for long time periods as noble gases, halogens and alkali metals* would condense late and therefore disproportionate with respect to less volatile elements. On the basis of long-lived gaseous precursors it would be predicted that the altered or melted particles would exhibit low R values for both chains, with the 89 smaller of the two. This was verified by the mean R values given in Table 4, which were 0.090 and 0.018 for the 140 and 89 chains, respectively. The corresponding values for the unaltered particles of 2.1 and 0.65 indicate that this latter class of particles may be important as a scavenger of these nuclides.

It is also of interest to compare R values obtained in this study with values obtained on gross fallout samples. The latter data gave Ba^{140} R values and Sr^{89} R values of 0.10 and 0.04 respectively** in the lagoon samples. The low R values for the gross sample from the lagoon area are similar to R values obtained with altered particles and suggests a lagoon fallout composed primarily of altered particles. This suggestion is supported by the WHIM sample fission/gram data (described above).

* Ba^{140} is formed by the decay of the radioelements Xe^{140} (16-sec half-life) and Cs^{140} (66-sec half-life); Sr^{89} is formed by the decay of the radioelements Kr^{89} (3.16-min half-life) and Rb^{89} (15.4-min half-life).

** P.D. LaRiviere, USNRDL, personal communication.

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DEPARTMENT OF DEFENSE

P-381

POLICY GUIDANCE FOR THE EMPLOYMENT OF NUCLEAR WEAPONS (NUWEP) (U)

OCTOBER 1980

~~22 DOD / DFOISR~~
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(24 Oct 80)

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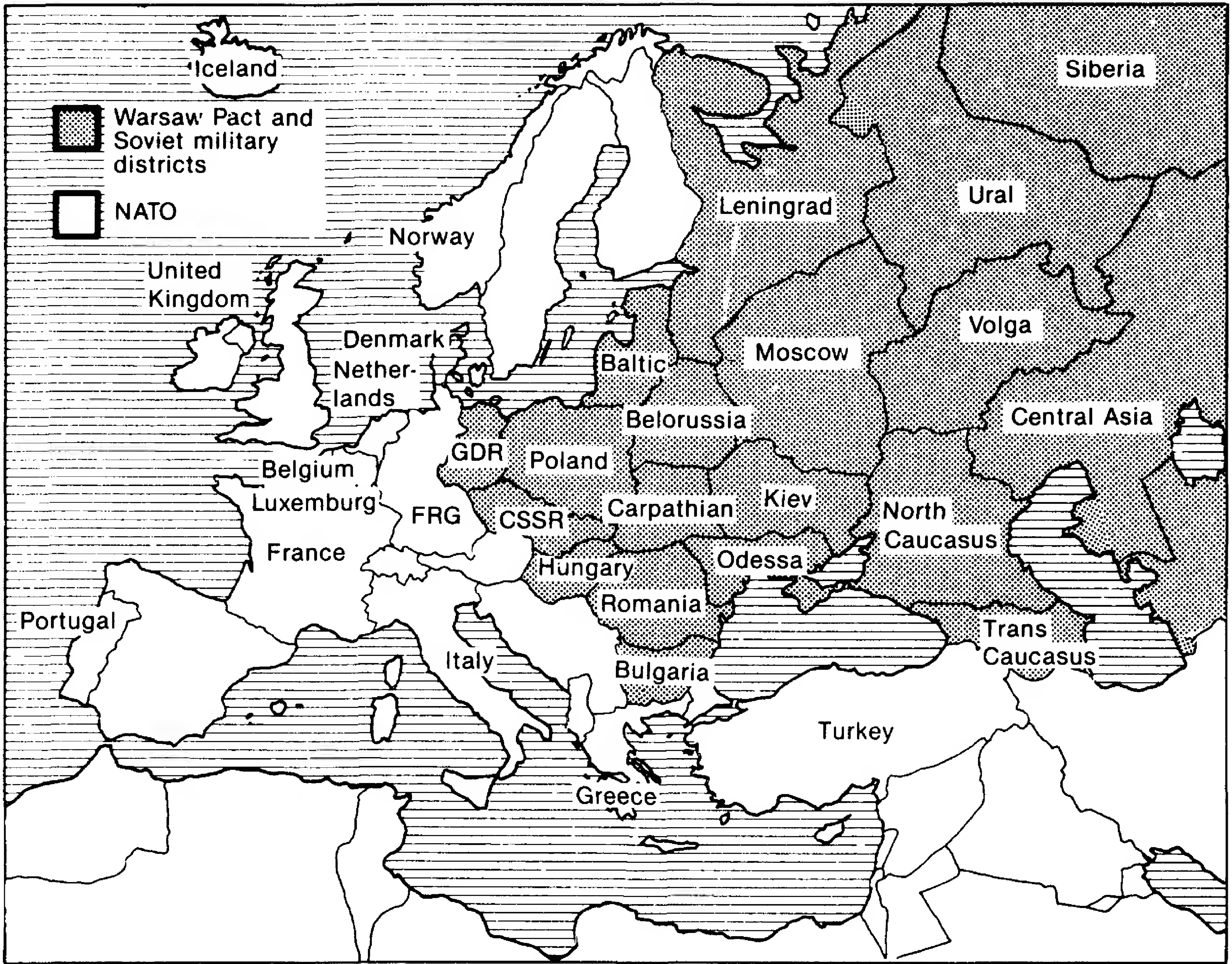
SEC DEF CONTR No. X-11328

IV. STRATEGY FOR EMPLOYMENT

A. Flexibility

(U) The U.S. must have the capability to respond appropriately and effectively to any level of Soviet aggression, over the continuum of nuclear weapon employment options, ranging from use of a small number of strategic and/or theater nuclear capable weapon systems in a contingency operation, to a war employing all elements of our nuclear forces in attacks against a broad spectrum of enemy targets. The ability to respond with selectivity to less than an all-out Soviet attack in keeping with the needs of the situation is required in order to provide the National Command Authorities (NCA) with suitable alternatives, strengthen deterrence, and enhance the prospects of limiting escalation of the conflict. In addition to pre-planned options we need an ability to design employment plans on short notice in response to the latest and changing circumstances. To advance the goal of flexibility, planning will provide an objective-oriented series of building block options for the employment of nuclear weapons in ways that will enable us to employ them consonant with our objectives and the course of the conflict.

~~(C)~~ As it evolves, the building block approach should provide plans which satisfy a hierarchy of targeting objectives and which will provide the NCA an improved capability to employ nuclear weapons effectively in as measured and controlled a manner as feasible in case of a limited conflict. It should provide complementary elements which can be combined in an integrated and discrete manner to provide larger and more comprehensive plans for achieving politico-military objectives in specific situations. The building block approach places emphasis on the individual elements, their objective utility, and our ability to employ them separately or in total. However, this does not imply that the total plan be finely divisible--practical realities cannot be ignored. The desire for enhanced flexibility in employment must be balanced by practical consideration of the increased complexity incurred in planning and operations, the need to avoid compromising the effectiveness and workability of the larger options, and the need to maintain a responsive decisionmaking and force execution process.


Iceland
Warsaw Pact and Soviet military districts
NATO
Norway
United Kingdom
Denmark
Nether-lands
Belgium
Luxemburg
France
Portugal
Italy
FRG
GDR
Poland
CSSR
Hungary
Romania
Bulgaria
Greece
Turkey
Baltic
Belorussia
Carpathian
Kiev
Odessa
Leningrad
Moscow
North Caucasus
Trans Caucasus
Volga
Ural
Central Asia
Siberia

Gorbachev's Economic Program: Problems Emerge

CIA HISTORICAL REVIEW PROGRAM
RELEASE IN FULL
1999

DDB-1900-187-88
June 1988

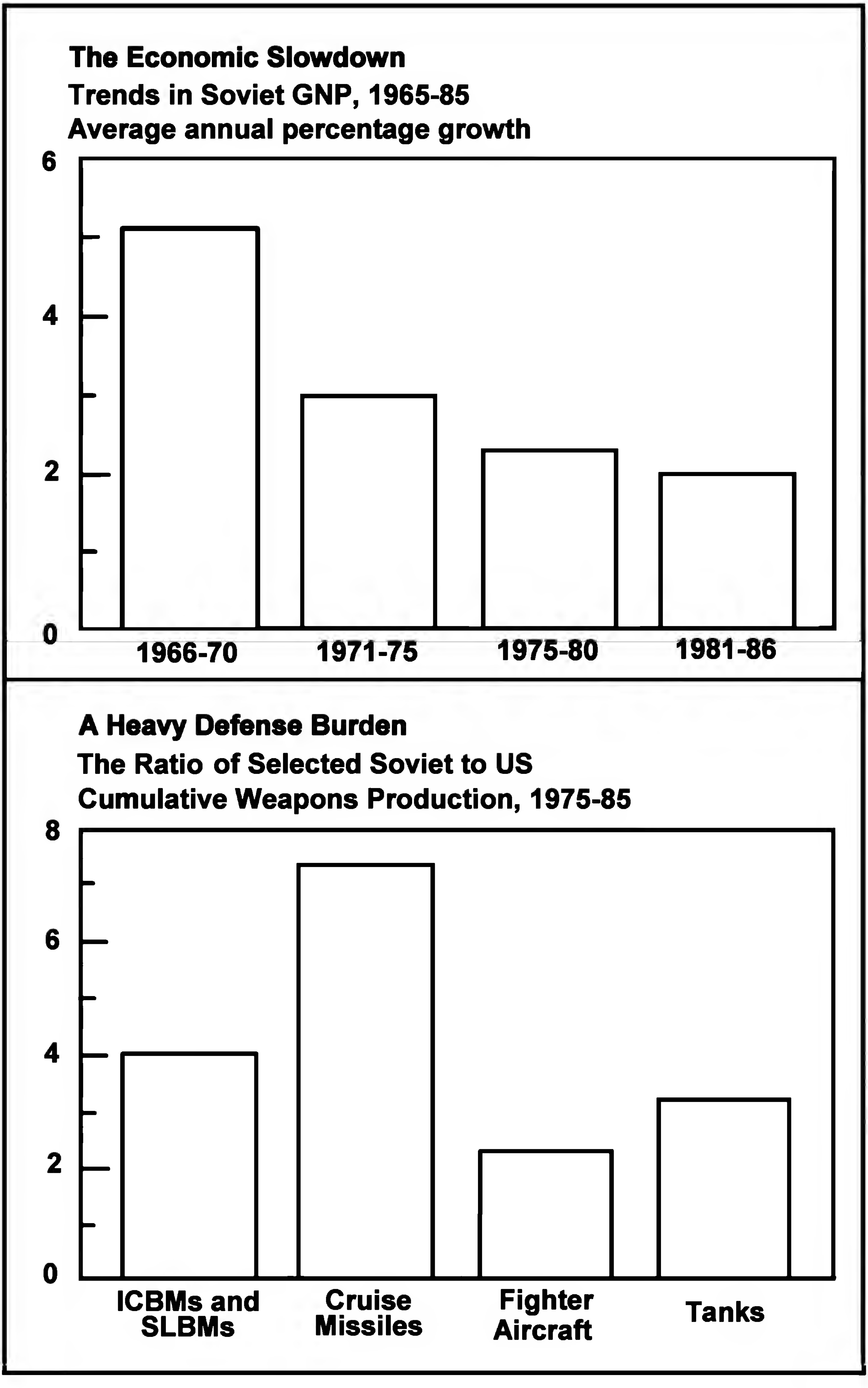


Figure 1. Gorbachev's Domestic Imperative

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THE WHITE HOUSE

WASHINGTON

91001

~~SECRET~~ ~~SENSITIVE~~

January 17, 1983

Declassified/Released 7/16/94
under provisions of E.O. 12356
by D. Van Tassel, National Security Council
F94-1102

National Security Decision
Directive Number 75

U.S. RELATIONS WITH THE USSR (S)

U.S. policy toward the Soviet Union will consist of three elements: external resistance to Soviet imperialism; internal pressure on the USSR to weaken the sources of Soviet imperialism; and negotiations to eliminate, on the basis of strict reciprocity, outstanding disagreements. Specifically, U.S. tasks are:

1. To contain and over time reverse Soviet expansionism by competing effectively on a sustained basis with the Soviet Union in all international arenas -- particularly in the overall military balance and in geographical regions of priority concern to the United States. This will remain the primary focus of U.S. policy toward the USSR.

2. To promote, within the narrow limits available to us, the process of change in the Soviet Union toward a more pluralistic political and economic system in which the power of the privileged ruling elite is gradually reduced. The U.S. recognizes that Soviet aggressiveness has deep roots in the internal system, and that relations with the USSR should therefore take into account whether or not they help to strengthen this system and its capacity to engage in aggression.

3. To engage the Soviet Union in negotiations to attempt to reach agreements which protect and enhance U.S. interests and which are consistent with the principle of strict reciprocity and mutual interest. This is important when the Soviet Union is in the midst of a process of political succession. (S)

In order to implement this threefold strategy, the U.S. must convey clearly to Moscow that unacceptable behavior will incur costs that would outweigh any gains. At the same time, the U.S. must make clear to the Soviets that genuine restraint in their behavior would create the possibility of an East-West relationship that might bring important benefits for the Soviet Union. It is particularly important that this message be conveyed clearly during the succession period, since this may be a particularly opportune time for external forces to affect the policies of Brezhnev's successors. (S)

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cy 16 of 12 copies

3. <u>Political Action</u>: U.S. policy must have an ideological thrust which clearly affirms the superiority of U.S. and Western values of individual dignity and freedom, a free press, free trade unions, free enterprise, and political democracy over the repressive features of Soviet Communism. We need to review and significantly strengthen U.S. instruments of political action including: (a) The President's London initiative to support democratic forces; (b) USG efforts to highlight Soviet human rights violations; and (c) U.S. radio broadcasting policy. The U.S. should:

-- Expose at all available fora the double standards employed by the Soviet Union in dealing with difficulties within its own domain and the outside ("capitalist") world (e.g., treatment of labor, policies toward ethnic minorities, use of chemical weapons, etc.).

-- Prevent the Soviet propaganda machine from seizing the semantic high-ground in the battle of ideas through the appropriation of such terms as "peace." (S)

B. <u>Geopolitical</u>

1. <u>The Industrial Democracies</u>: An effective response to the Soviet challenge requires close partnership among the industrial democracies, including stronger and more effective collective defense arrangements. The U.S. must provide strong leadership

LA-14066-H
History

Tracing the Origins of the W76: 1966–Spring 1973 (U)

Betty L. Perkins

November 3, 2003

Redacted Version

~~NUCLEAR WEAPON DATA~~
~~Sigma 1~~

~~Critical Nuclear Weapon Design Information~~
~~DoD Directive 5210.2 Applies~~

~~RESTRICTED DATA~~
~~This document contains Restricted Data as defined in the Atomic Energy Act of 1954. Unauthorized disclosure subject to administrative and criminal sanctions.~~

Classifier: Michael Pankratz
Derived from: LA-4000, Rev. 8, 9/02
July 14, 2003

Los Alamos
NATIONAL LABORATORY
Los Alamos NM 87545

7. Yield: The Confetti Argument

Agnew felt that the yield of the W68 was too low to be really effective. In addition, in terms of the overall total yield available from all the W68 warheads, the W68 design was very costly in terms of the amount of required special nuclear materials.

In an April 1972 TWX to Assistant Director for Safety and Liaison (Division of Military Application) Colonel Robert T. Duff, Agnew reported that he was worried about maintaining the U.S. nuclear deterrent. Agnew noted, "It occurs to me that as we go to lower and lower yields in our strategic missile warheads and the Soviet Union builds up a better and better civil defense position, the reality of this deterrent may become questionable.

(b)(3)

If the Soviet leadership believes this, then our strategic deterrent will have lost a good deal of its force. If our MIRV trend continues we'll be threatening to throw confetti at a potential aggressor. Confetti has high penetration and survivability but little deterrent power."[281]

In a letter dated October 10, 1972, to Giller, at that time Assistant General Manager for National Security, Agnew again noted several reasons why low yield warheads might not be the best solution for maximizing the deterrence capability of the stockpile. He reported that considering the number of required submarines and the low efficiency in their use of special nuclear material, the low-yield warheads were not very cost effective. Moreover, Agnew pointed out that for the Hiroshima device, the effects on Hiroshima in terms of loss of substantial buildings and the people in them "wasn't all that impressive." In terms of loss of life, the USSR had lost more than ten million people in WWII. Although the Soviets had an extensive civil-defense network in place, even if that did not work to reduce loss of civilian lives, the Soviets might not mind losing a few people. Agnew wrote, "Again, to me, to continue to increase warhead numbers at the cost of a decrease in yield per warhead could eventually lead to no deterrence in the minds of those we hope to deter." Agnew stated, "I feel very strongly that we should endeavor to convince the DoD that what they should have on the next round is a mix of yields.

(b)(3)

8. Capability

Agnew in his August 10, 1972, letter to Camm pointed out that the Los Alamos group had been developing suitable technology applicable to the new strategic missile warheads. He wrote, "In summary then, we have been working very hard to provide the very latest technology in warhead designs incorporating the most advanced minimum weight hardening techniques to provide an optimum warhead for the next round of strategic missile warheads. In fact, our work has been of such outstanding quality that we have been invited by Admiral Levering Smith to

[281] H. M. Agnew, University of California, Los Alamos Scientific Laboratory, Los Alamos, N.M. to BY3/Colonel Robert T. Duff, USAF, Assistant Director for Safety and Liaison, Division of Military Application USAEC, Wash., D.C. (SRD) (April 14, 1972), pp. 1–2, B11, Drawer 56, Folder 1 of 4.

(b)(3)

3. Reservoir Designs to Provide Minimum Helium in the Boost Gas

In a March 1969 memo, primary designer R. Canada outlined the problems that were the result of the formation of ^{3}He from the decay of the tritium used in the primary's boost gas.

(b)(3)

The yield of a boosted primary is degraded as tritium is converted to ^{3}He both by the loss of the source of 14-MeV neutrons and also by the decrease of the pre-boost multiplication rate caused by the high cross-section for neutron capture which is characteristic of ^{3}He." He went on to add, "In a conventional boosted single-stage device the tritium produced by ^{3}He appears too late in the bomb's explosion to contribute to the yield, and the temperature does not get high enough to produce significant ^{3}He + D fusion."[293]

(b)(3)

[293] R. Canada to Distribution, Subject: "^{3}He in Weapons," W-4-2518 (SRD) (March 10, 1969), 5 pp., A99-019, *199-13.*

(b)(3)

1974 CIA report on emerging USSR superiority:

NIE 11-3/8-74 *Soviet Forces for Intercontinental Conflict*

SUMMARY

THE USSR'S CURRENT STRATEGIC SITUATION

1. The Soviets are pressing ahead with a broad range of programs for the near-term deployment of much improved offensive systems for intercontinental conflict. In addition they are gradually improving their deployed strategic defenses, and are vigorously pursuing the development of advanced technology applicable to strategic forces.

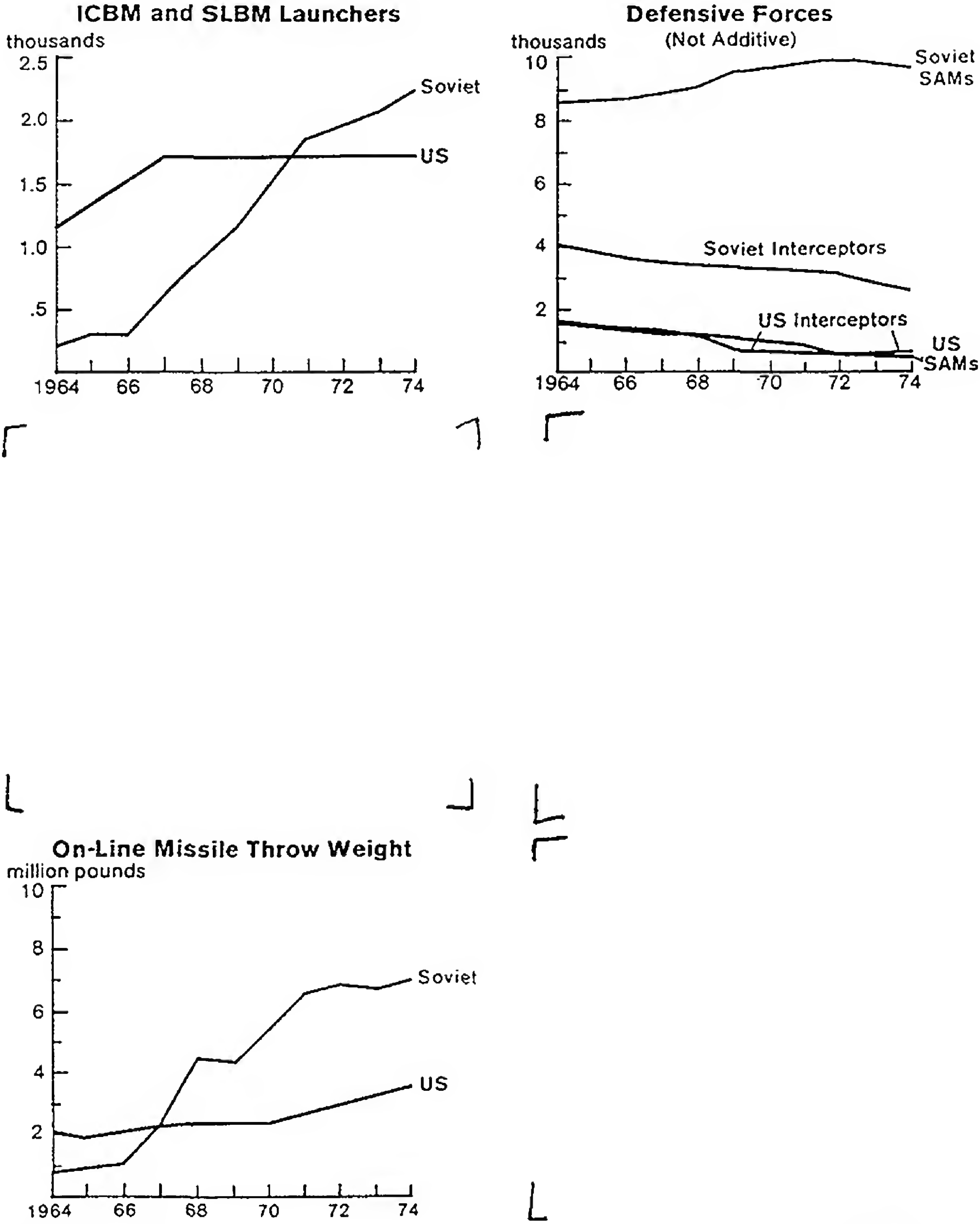
— *In offensive forces*, they are focusing on improving the accuracy, flexibility, and survivability of their ICBMs and SLBMs and on MIRVing their ICBMs. Four new ICBMs, three with MIRV payloads, are being flight tested. A mobile version of one of the missiles probably is being developed. Hardened launch control centers are being constructed at missile complexes, and a standby airborne command post for the Strategic Rocket Forces probably now is operational. New classes of nuclear-powered ballistic missile submarines with long-range missile systems continue under construction, and a new multipurpose bomber is starting to be deployed. Additional ICBMs and SLBMs are in the preflight stages of research and development.

— *In defensive forces*, the Soviets are improving the capability of forces already deployed and are developing new systems. Older fighter-interceptors and surface-to-air missile systems are being phased out gradually as improved equipment is introduced. Current research and development activity includes programs for antisubmarine warfare, an antiballistic missile system which can be deployed much more rapidly than the one now operational, an endoatmospheric ballistic missile interceptor, and the application of lasers to strategic defense.

2. These developments follow a series of large-scale deployment programs over the past ten years which have provided the Soviets with a reliable deterrent and have brought about world recognition of the USSR's status as a superpower roughly on a par with the US. Through these earlier programs, the USSR has largely eliminated previous US quantitative advantages in strategic offensive forces.

Figure 1

Historical Trends in Selected Aspects of Strategic Forces



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THE DIRECTOR OF CENTRAL INTELLIGENCE

WASHINGTON, D. C. 20505

MEMORANDUM FOR: Recipients of National Intelligence Estimate 11-3/8-76, "Soviet Forces for Intercontinental Conflict Through the Mid-1980s"

FROM George Bush

1. The attached National Intelligence Estimate is the official appraisal of the Director of Central Intelligence. This Estimate, including its italicized statements of differing views by members of The National Foreign Intelligence Board, was drafted and coordinated by professional intelligence officers of the US Intelligence Community and was approved by me with the advice of the Board.

2. The judgments arrived at in this Estimate were made after all parties to the Estimate had the benefit of alternative views from the various elements of the Community and from panels of experts from outside government on a few selected subjects. The assembling of the panels of outside experts, and the consideration of their views, was agreed upon by me and the President's Foreign Intelligence Advisory Board as an experiment, the purpose of which was to determine whether those known for their more somber views of Soviet capabilities and objectives could present the evidence in a sufficiently convincing way to alter the analytical judgments that otherwise would have been presented in the attached document. The views of these experts did have some effect. But to the extent that this Estimate presents a starker appreciation of Soviet strategic capabilities and objectives, it is but the latest in a series of estimates that have done so as evidence has accumulated on the continuing persistence and vigor of Soviet programs in the strategic offensive and defensive fields.

NIE 11-3/8-76 Soviet Forces for Intercontinental Conflict Through the Mid-1980s

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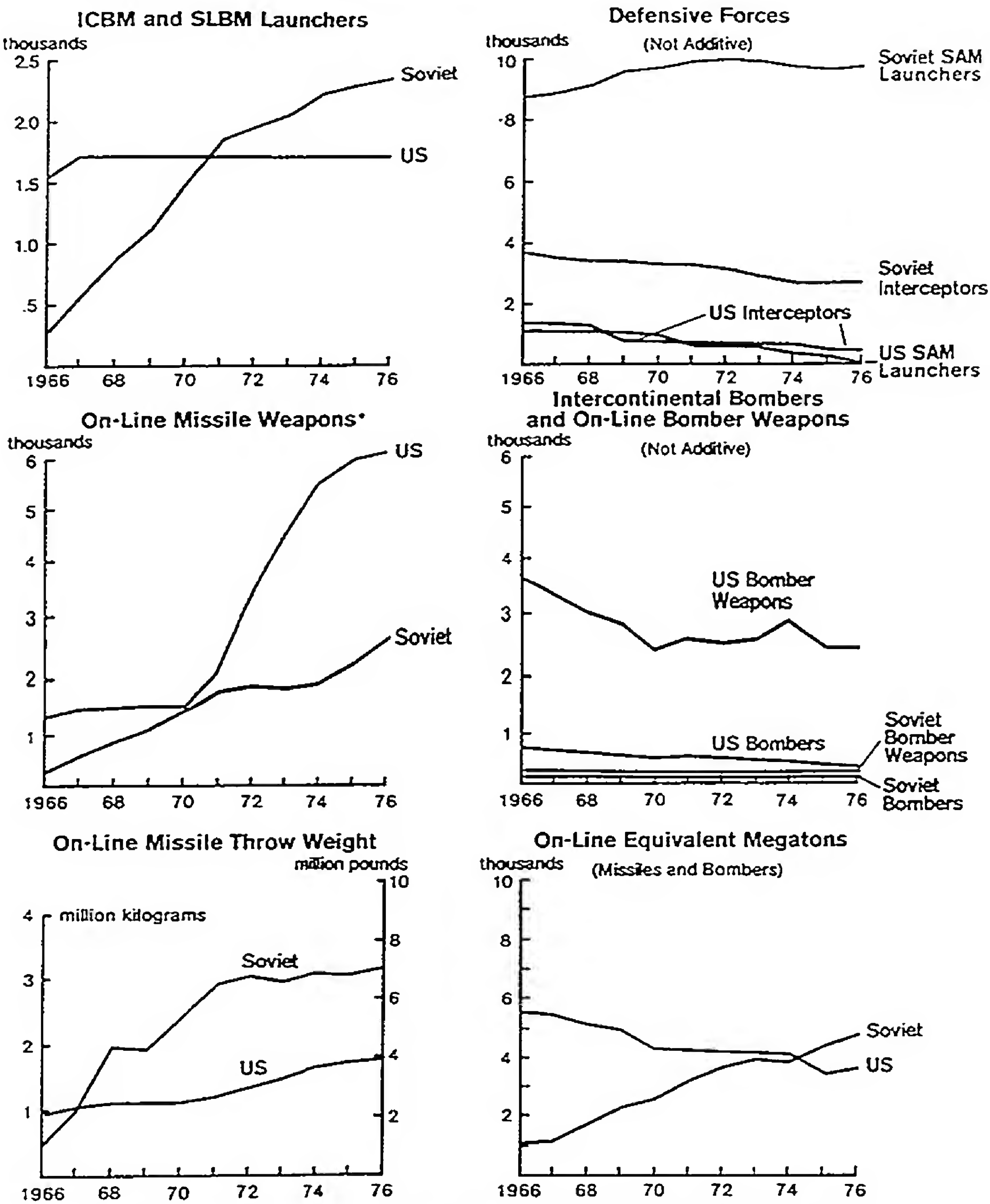
Figure 1

Historical Trends in Selected Aspects of Strategic Forces



* Excludes ICBM silo launchers under construction or conversion and SLBM launchers on SSBNs undergoing sea trials, conversion, or shipyard overhaul. Missile payloads composed of MRVs (which are not independently targetable) are counted as one RV.

NIE 11-3/8-80 *Soviet Capabilities for Strategic Nuclear Conflict Through the Late 1980s*

PART ONE—KEY JUDGMENTS

PREFACE

These Key Judgments consist of two sections. This year the Director of Central Intelligence has added his own key judgments (section A), which have not been coordinated with the Intelligence Community. He does not hold major disagreements with the key judgments coordinated by the Intelligence Community agencies (section B) or with the basic analysis in the Estimate. He does not believe, however, that the findings in section B adequately emphasize those areas of key importance to the President and his principal advisers on foreign policy. His key judgments, therefore, address what the basic Estimate tells us about the following four issues of cardinal importance to US policy on strategic forces:

— How the strategic capabilities of the two sides compare.

— What actions the Soviets may take as they view the comparative strengths of the strategic forces.

— Whether and how the balance of strategic forces prompts the Soviets to pursue strategic arms control agreements with the United States.

— Whether or not the advantages that the Soviets seem to have in ICBMs through 1986 would induce or pressure them to exploit what they might perceive as a "window of opportunity" before those advantages may be erased toward the end of this decade.

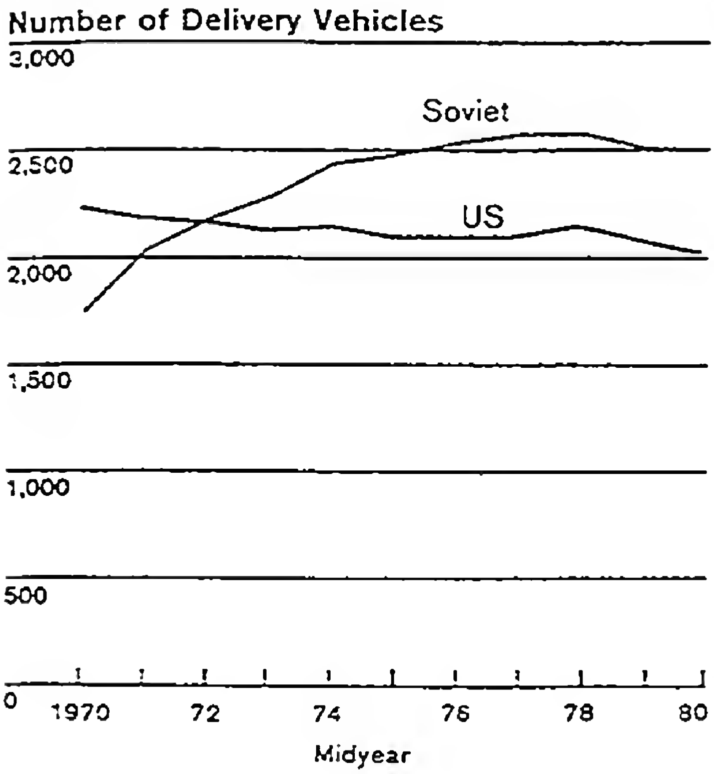
A. KEY JUDGMENTS OF THE DIRECTOR OF CENTRAL INTELLIGENCE

Soviet Perceptions of the Strategic Environment

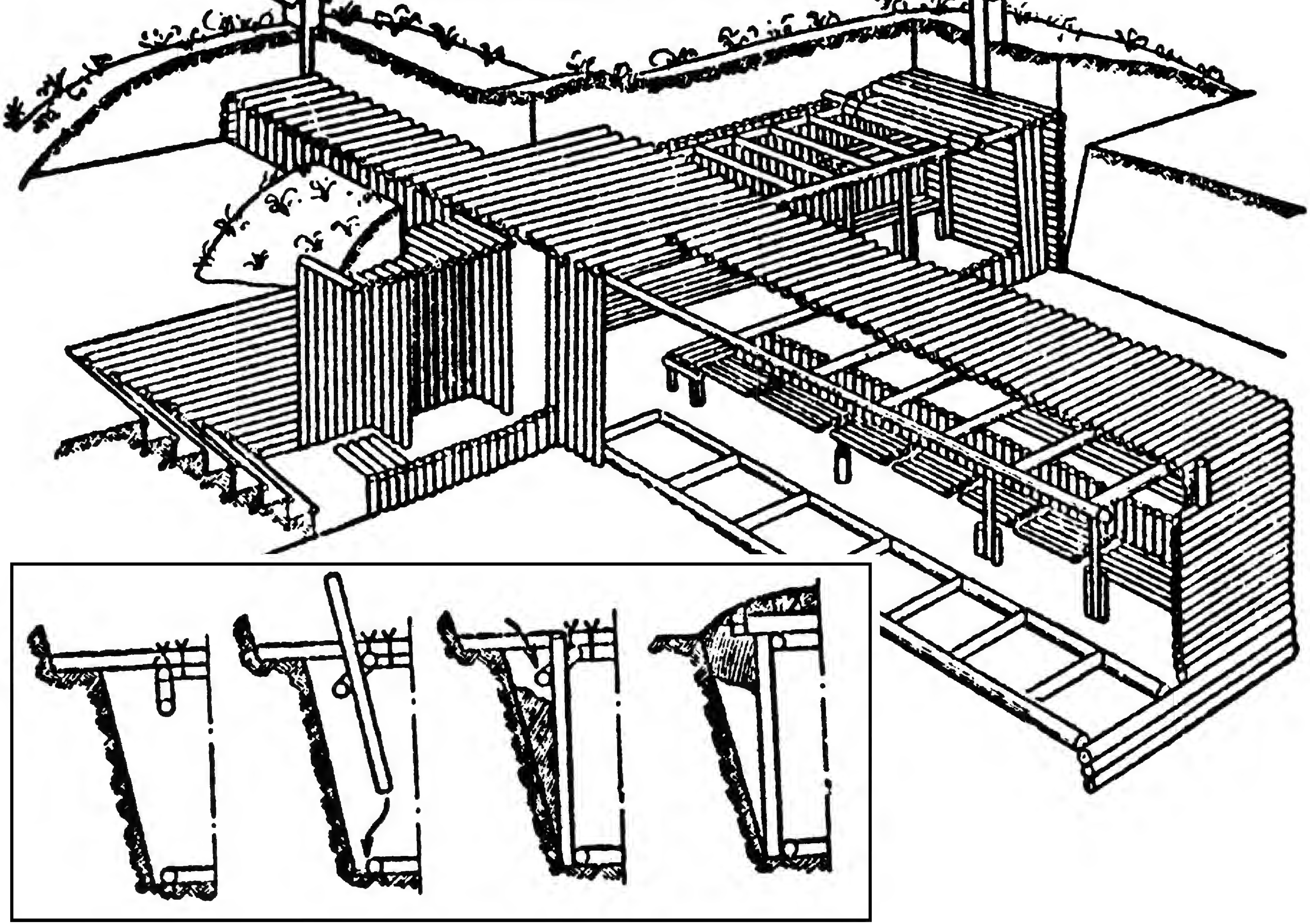
1. The comprehensive nature of Soviet strategic offensive and defensive programs, the emphasis in Soviet military doctrine on capabilities to fight a nuclear war, and assertions that general nuclear war can be won indicate that some Soviet leaders hold the view that victory in general nuclear war is possible. The Soviets assert that a general nuclear war will probably be brief, but we believe that they have

Figure I

Comparison of Soviet and US Forces for Intercontinental Attack, 1970–80

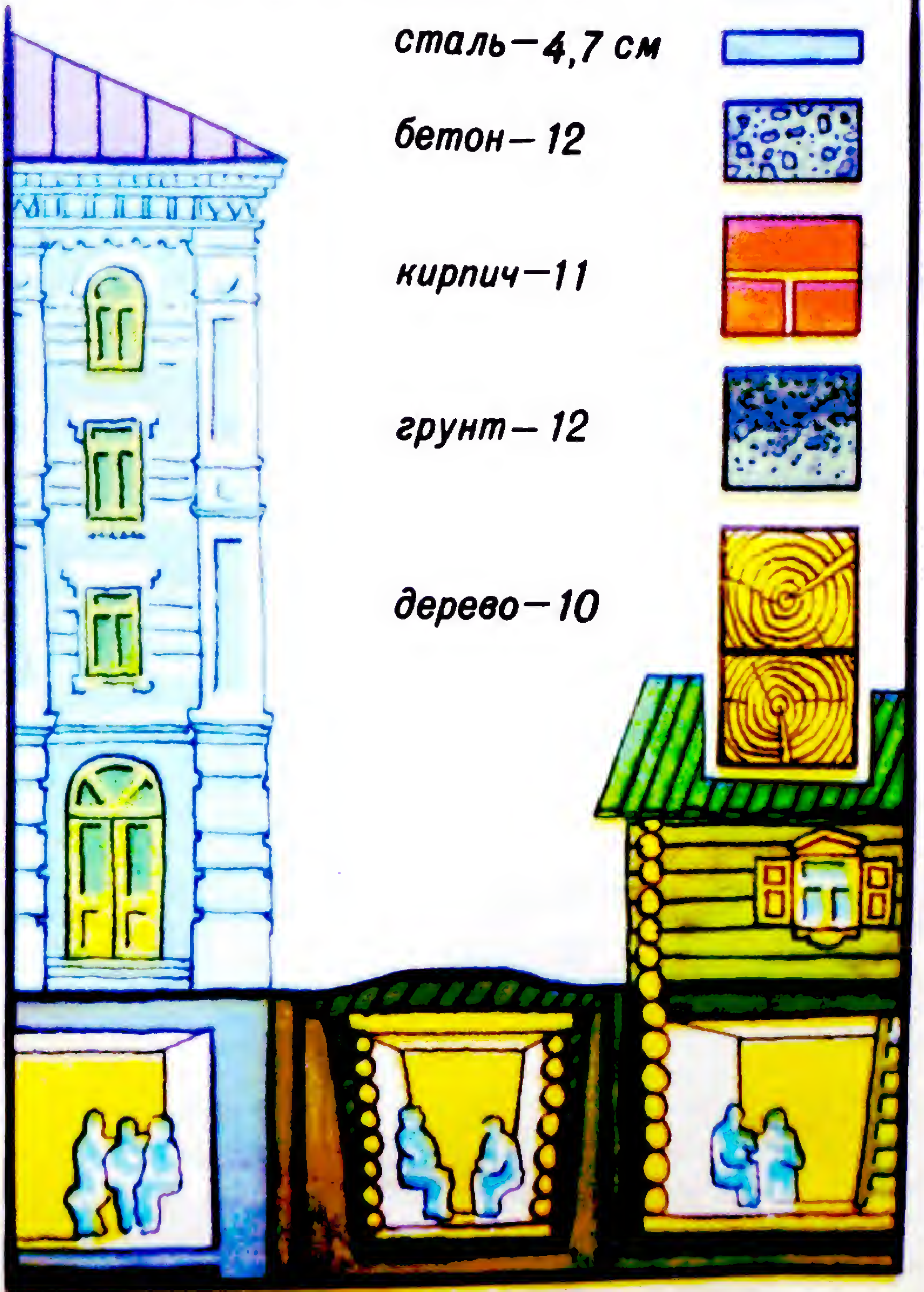


Soviet design for pole shelter



ЗАЩИТНЫЕ СВОЙСТВА МАТЕРИАЛОВ

Экспозиционную дозу радиации ослабляют вдвое материалы толщиной



FOR EXTERNAL PUBLICATION

Radio Moscow in Mandarin to China, Nov. 3, 1978.

"However, the fact is that China's digging deep tunnels can never protect the Chinese masses from nuclear bombing or even protect them from conventional heavy bombs."

* * * * * * * * * *

Radio Moscow World Service in English, Nov. 16, 1978

"The U.S. Administration is going to launch a 5-year program of civil defense. - - - The only real safety for the Americans is strengthening friendship with the Soviet Union, not bomb shelters."

FOR INTERNAL PUBLICATION

Moscow *Voyennyye Znaniya* in Russian No. 5, May 1978, p. 33.

"It is appropriate to say that we still meet people who have an incorrect idea about defense possibilities. The significant increase in the devastating force of nuclear weapons compared with conventional means of attack makes some people feel that death is inevitable for all who are in the strike area. However, there is not and can never be a weapon from which there is no defense. With knowledge and the skillful use of contemporary procedures, each person can not only preserve his own life but can also actively work at his enterprise or institution. The only person who suffers is the one who neglects his civil defense studies."

Robert Scheer

WITH ENOUGH SHOVELS: Reagan, Bush & Nuclear War

"Dig a hole, cover it with a couple of doors and then throw three feet of dirt on top... It's the dirt that does it... if there are enough shovels to go around, everybody's going to make it."

—T. K. Jones, Deputy Under Secretary of Defense for Strategic and Theater Nuclear Forces

"President Ronald Reagan had been in office less than a year when he approved a secret plan for the United States to prevail in a protracted nuclear war. This secret plan, outlined in a so-called National Security Decision Document, committed the United States for the first time to the idea that a global nuclear war can be won."

With these words Robert Scheer, the distinguished national reporter for the *Los Angeles Times*, begins this astonishing revelation of how a handful of Cold War ideologues—led by the President himself—have reversed the longstanding American assumption that nuclear war means mutual suicide.

Robert Scheer's aim in *With Enough Shovels* is to expose the deadly course on which we are now embarked, a course that categorically rejects the strategic assumptions that prevailed from Presidents Eisenhower through Carter and that sustained the Nixon-Kissinger program of détente—a program which our current leaders call "appeasement."

Leon Gouré

WAR SURVIVAL IN SOVIET STRATEGY

USSR CIVIL DEFENSE

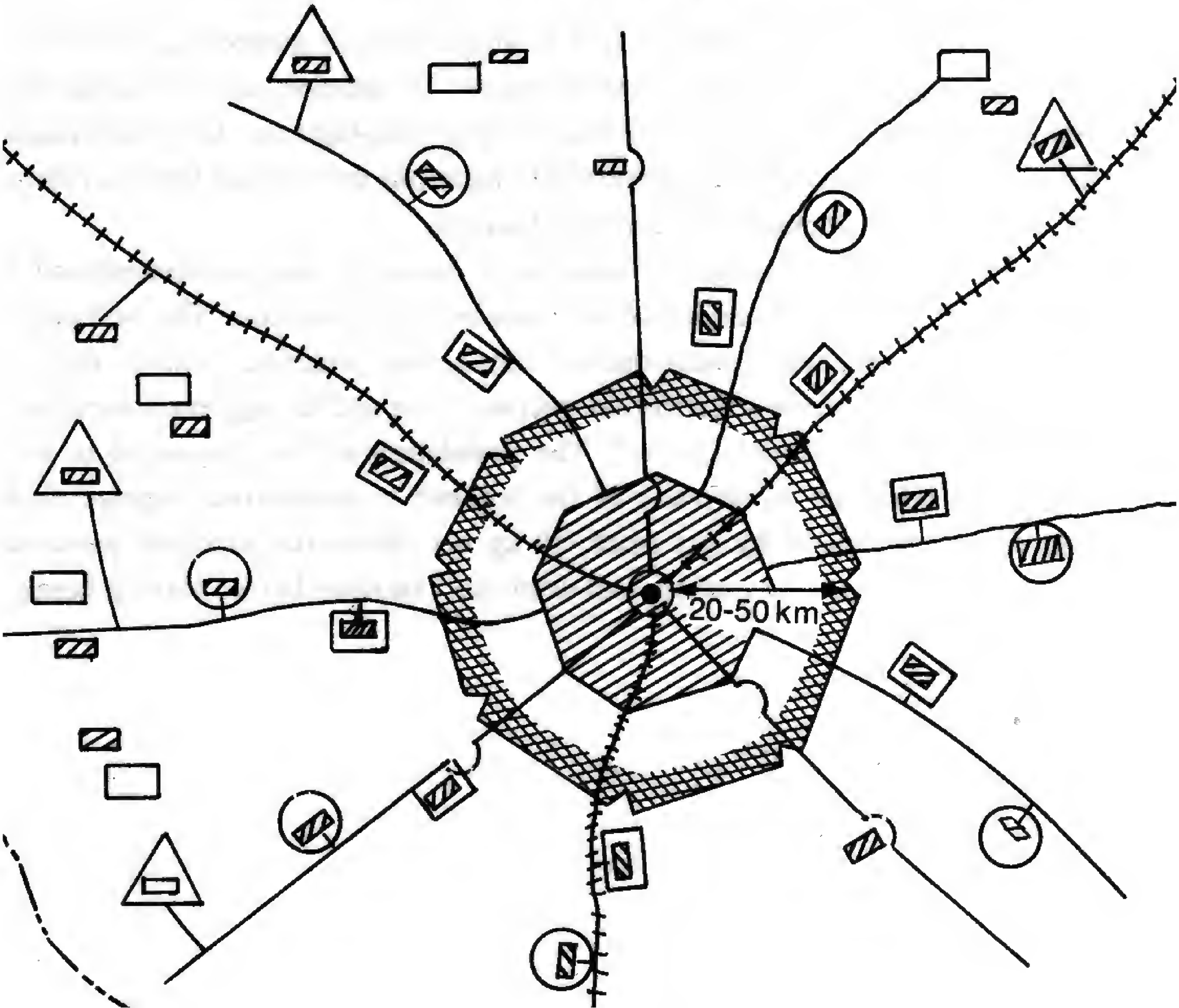
With a Foreword by
AMBASSADOR FOY D. KOHLER

LEON GOURÉ is a Professor of International Studies and Director of Soviet Studies at the Center for Advanced International Studies at the University of Miami. A graduate of New York University, Columbia University School of International Affairs and Russian Institute, and Georgetown University, he is the author of *Civil Defense in the Soviet Union, The Siege of Leningrad,* and *Soviet Civil Defense 1969-70*. He has also co-authored *Soviet Strategy for the Seventies: From Cold War to Peaceful Coexistence, The Role of Nuclear Forces in Current Soviet Strategy,* and *Soviet Penetration of Latin America* among others.

1st printing .... April 1976
2nd printing .... August 1976

Civil defense youth training

CHART 4—Schematic Diagram of the Relocation of Dispersed Workers and Evacuated Persons and Plants.



Foreword

by Foy D. Kohler

Dr. Leon Gouré has devoted many years of study to Soviet civil defense and other war-survival policies and activities in the USSR. The area was one of his specialties while serving as a Senior Analyst for the RAND Corporation from 1951 to 1969, and he has continued his researches since joining the University of Miami in 1969 as Director of Soviet Studies and Professor in the Center for Advanced International Studies.

As a part of our work program for this larger undertaking, the Center has held a series of special conferences wherein we have subjected our methodology and research findings to critical review by outside experts, including authoritative academic and governmental specialists on Soviet affairs and high-ranking policy-action officers from Defense, State and other agencies directly concerned with U.S.-Soviet relations.

At two of these conferences, special attention has been given to the Soviet war-survival problem: One in June 1975 included an exploration of how war-survival capabilities fit into the Soviet appraisal of the present and future "correlation of world forces." The second, held in January 1976, included a thorough examination of the implications for U.S. security interests and U.S. policy choices of what Moscow is actually doing in the war-survival area.

Nearly all of the experts at our conference viewed the reasoning behind the overkill concept as "absurd." One cited as an example an article in the April 6, 1975 *Bulletin of the Atomic Scientists* in which the author argued that with its present stockpile of nuclear weapons the U.S. could destroy the world's population "twelve times over." The author's calculation was arrived at by multiplying the casualties per kiloton in Hiroshima and Nagasaki by the total number of kilotons in the U.S. nuclear arsenal and then dividing by the number of people living in the world. Such a calculation was characterized as completely misleading. Leaving aside such questions as how many U.S. weapons would survive a Soviet attack on this country and how many of the residue could be delivered on target, "it implies that means can be devised to collect the entire target population into the same density as existed in Hiroshima and Nagasaki and keep them in a completely unwarned and hence vulnerable posture. A statement of identical validity is that the world's inventory of artillery shells, small arms ammunition, or for that matter, kitchen knives or rocks can kill the human population several times over."

It was recalled that more than 10 billion pounds of TNT was dropped on Germany, Japan and Italy during World War II. This equalled more than 50 pounds for every man, woman and child in the three countries. Arithmetically considered, the result should have been the total annihilation of one and all of these. During the Vietnam War, more than 25 billion pounds of TNT were dumped on North and South Vietnam (15 billion by air and some 10 billion by other means) for an average of some 730 pounds for each of a total population of 34 million and an average of 3,000 pounds for each person in prime target areas; yet the U.S. was unable to kill enough people or to disrupt economic life, transportation and communications sufficiently to even avoid a humilitating defeat in the war.

The basic issue, it was agreed, is how Moscow intends to exploit the situation politically. The Soviet risk calculations and ability to use its military power for political purposes are already being increasingly influenced by Moscow's perceptions of asymmetries between the U.S. and Soviet war-survival versus assured destruction capabilities. According to Moscow's view, these asymmetries are of great strategic significance for making Soviet power credible as a deterrent and as an instrument of policy. Soviet spokesmen have given clear indication of their awareness of the lack of a war-survival program in the U.S. as well as of the vulnerability of the U.S. arising from the high degree of concentration of its population and industry in a few areas of the country. It is inevitable, therefore, that the Soviet leadership will perceive this asymmetry between the Soviet Union and the U.S. as altering the balance of forces in Moscow's favor, and as affecting the credibility of the respective strategic deterrence and war-fighting postures of the two countries.

In effect, with its growing war-survival capability, the Soviet Union could well conclude that the U.S. threat of "massive retaliation" has no credibility except as an act of sheer desperation. In crisis situations, this factor could decisively influence both sides' risk calculations and consequently their relative ability and willingness to hold a hard line. The Soviet Union could confront the U.S. with its ability to keep Soviet population and resource losses within acceptable limits, all the more so if it carries out the evacuation of its cities, as against the certainty of U.S. losses of 50 percent or more of its population and of a very large portion of its industry. This would place the U.S. at a great disadvantage in the management of the crisis and in its negotiations with the Soviet Union. Instead of a "balance of terror" which equally restrains both sides, the "terror" would be mainly on the part of the U.S. and, faced with the possibility of national "suicide," the public reaction to it would be likely to deprive the President of any flexibility in his policy choices in dealing with Moscow.

C00012335

CENTRAL INTELLIGENCE AGENCY
WASHINGTON 25, D. C.

CIA 12 March 1962

12 MAR 1962

MEMORANDUM FOR: The Director of Central Intelligence

SUBJECT : MILITARY THOUGHT: "Some Factors Affecting the Planning of a Modern Offensive Operation", by Colonel-General Ye. Ivanov

1. Enclosed is a verbatim translation of an article which appeared in the TOP SECRET Special Collection of Articles of the Journal "Military Thought" ("Voyennaya Mysl") published by the Ministry of Defense, USSR, and distributed down to the level of Army Commander.

2. In the interests of protecting our source, this material should be handled on a need-to-know basis within your office. Requests for extra copies of this report or for utilization of any part of this document in any other form should be addressed to the originating office.

Richard Helms

Richard Helms
Deputy Director (Plans)

Following is a verbatim translation of an article titled "Some Factors Affecting the Planning of a Modern Offensive Operation", written by Colonel-General Ye. Ivanov.

This article appeared in the 1960 Second Issue of a special version of Voyennaya Mysl (Military Thought) which is classified TOP SECRET by the Soviets and is issued irregularly.

* * *

Weakening the nuclear strength of an opposing grouping of the enemy and depriving him of his capability to use nuclear weapons is one of the most important tasks, whose correct solution ensures the success of the offensive operation as a whole.

* * *

The mass utilization of nuclear weapons in short periods of time is the only way to achieve decisive destruction of the fire power of an opposing enemy grouping, destruction of his main nuclear/missile and aviation means, and also disruption of the control of troops and the disorganization of work of the rear services.

ЕГОРОВ П. Т., ШЛЯХОВ И. А., АЛАБИН Н. И.

ГРАЖДАНСКАЯ ОБОРОНА

Изд. 2-е, переработанное

«Допущено Министерством высшего и среднего специального образования СССР в качестве учебника для высших учебных заведений»

ИЗДАТЕЛЬСТВО
«ВЫСШАЯ ШКОЛА»
Москва — 1970

CIVIL DEFENSE

(Grazhdanskaya Oborona)

Authors

P. T. Yegorov, I. A. Shlyakhov, and N. I. Alabin

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The presence of apertures in walls (windows, doors) has an influence on the destruction of buildings and structures since the wave, easily destroying them, penetrates quickly into the building, and the reflected pressure [outside] is compensated by the overpressure within.

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In addition, nuclear blasts create electromagnetic fields, which generate surges in underground lines and in high-wire lines and radio station antennas, and also generate radio waves propagated over a wide area. The induced current and voltage may be propagated by wires over a wide area and cause damage to insulation, electrical and radio equipment may burn out, and personal injuries may occur. It is necessary to implement engineering technical measures in civil defense in order to provide protection from secondary damage.

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3. Methods of Protecting the Population by Dispersal and Evacuation

3.1 Organization and Planning of Dispersal and Evacuation

During the Great Patriotic War [World War II], to protect productive capacity, we transported entire enterprises, including their workers and employees, to the deep rear from areas of direct combat; that is, we evacuated industry. The evacuation of people, enterprises, and capital equipment was directed by the Soviet [Council] on Evacuation, which was organized by a decree of the CC of the CPSU and by the Council of People's Commissars of the 24th of June, 1941.

Under the direction of the government, all national departments and administrations organized special sections and commissions on evacuation. On-site, the evacuations were supervised by Party and Soviet organs. A priority system for evacuating enterprises, people and material goods was established.

The first enterprises to be evacuated were large ones with defense significance. (The evacuation included workers, employees and their families, and factory equipment.) From July through November 1941, over 1000 industrial enterprises moved into the interior of the country. Evacuation from the forward areas of the Don Basin, Stalingrad, and the northern Caucasus was also conducted in the summer of 1942.

A characteristic feature of the evacuation of that time was that it took place over 1000 kms. from the front lines, into areas inaccessible—at the time—to enemy attack. However, this evacuation was only partial in character, since a significant part of the population remained in the territory occupied by the German-fascist invaders.

Under conditions of a nuclear missile war, civil defense must solve the problem of defending the population through a series of measures, which include dispersal and evacuation of people from cities that are likely to be targets of missile strikes by the enemy.

Table 40. Permissible exposure time in an area contaminated by fallout resulting from a nuclear blast

D/R value*	Time of entry into the contaminated area (from the time of the blast) (hr)												
	0.5	1	2	3	4	5	6	7	8	9	10	12	24
	Exposure time (in hours and minutes) for which the determined value *D/R* is obtained for different times of entry into the contaminated area, referred to the blast time.												
0.2	0–15	0–14	0–13	0–12	0–12	0–12	0–12	0–12	0–12	0–12	0–12	0–12	0–12
0.3	0–22	0–22	0–20	0–19	0–19	0–19	0–19	0–18	0–18	0–19	0–18	0–18	0–18
0.4	0–42	0–31	0–27	0–26	0–26	0–25	0–25	0–25	0–25	0–25	0–25	0–24	0–24
0.5	1–02	0–42	0–35	0–34	0–32	0–32	0–32	0–31	0–31	0–31	0–31	0–31	0–30
0.6	1–26	0–54	0–44	0–41	0–39	0–39	0–38	0–38	0–38	0–37	0–37	0–37	0–37
0.7	2–05	1–08	0–52	0–49	0–47	0–46	0–45	0–45	0–44	0–44	0–44	0–44	0–43
0–8	2–56	1–23	1–02	0–57	0–54	0–53	0–52	0–51	0–51	0–51	0–50	0–50	0–49
0.9	4–09	1–42	1–12	1–05	1–02	1–00	0–59	0–58	0–58	0–57	0–57	0–57	0–55
1.0	5–56	2–03	1–23	1–14	1–10	1–08	1–06	1–05	1–05	1–04	1–04	1–03	1–02
2.0	1562–00	11–52	4–06	3–13	2–46	2–35	2–29	2–24	2–20	2–18	2–16	2–13	2–06
2.5		31–00	6–26	4–28	3–48	3–28	3–16	3–08	3–03	2–59	2–55	2–51	2–40
3.0		96–39	9–54	6–09	5–01	4–28	4–10	3–58	3–49	3–43	3–38	3–30	3–14
4.0		3124–00	23–43	11–05	8–12	6–57	6–16	5–50	5–33	5–19	5–10	4–58	4–26
6.0			193–19	35–35	19–48	14–43	12–19	10–55	10–02	9–24	8–57	8–19	7–01
10.0				728–49	124–00	59–18	39–34	30–39	25–42	22–35	21–32	17–52	13–08

* *D/R* equals permissible dose in roentgens divided by the dose rate r/hr at the moment of entry into the contaminated area.

CIVIL PREPAREDNESS AND LIMITED NUCLEAR WAR

HEARINGS

BEFORE THE

JOINT COMMITTEE ON DEFENSE PRODUCTION CONGRESS OF THE UNITED STATES

NINETY-FOURTH CONGRESS

SECOND SESSION

APRIL 28, 1976

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HEARING ON CIVIL PREPAREDNESS AND LIMITED NUCLEAR WAR

WEDNESDAY APRIL 28, 1976

U.S. SENATE AND
U.S. HOUSE OF REPRESENTATIVES,
JOINT COMMITTEE ON DEFENSE PRODUCTION,
Washington, D.C.

The committee met at 10:05 a.m. in room 5302, Dirksen Senate Office Building, Hon. William Proxmire, vice chairman of the subcommittee, presiding.

Present: Senators William Proxmire and John Sparkman.

Senator PROXMIRE. The committee will come to order.

Today's hearing inaugurates a review by the Joint Committee on our Nation's civil preparedness. It is the first such congressional review in over two decades.

By civil preparedness, we mean those mainly civilian measures by which we seek to protect the lives and property of our citizens.

This is the first function of any government. A government which cannot meet this fundamental test of defending its people and the national treasure is not likely to survive for very long.

In subsequent hearings, the committee will examine the adequacy of Federal, State, and local preparedness programs, including plans for fallout shelters, strategic evacuation, preparedness exercises and drills, civil defense stockpiles, and continuity of government. Likewise, the Joint Committee will inquire into the organization of the Government for preparedness. It will also review the Nation's industrial and economic preparedness in terms of the defense industrial base.

This is an especially timely undertaking. Over the past 2 years the United States has been moving from a declared nuclear policy of mutual assured destruction to one of flexible response, or limited nuclear war.

In the minds of some eminent strategists, this implies a lowering of the nuclear weapons threshold, a quickening of the trigger finger on the missile launch console, and an increased probability of uncontrolled nuclear conflict.

But to other equally qualified experts, this shift in strategic doctrine, this shift to larger numbers of more flexible, or more versatile and accurate weapons and control systems does not undermine deterrence of nuclear war; instead, it enhances deterrence.

Well, it can't be both ways and whenever you have such a complete divergence in expert opinion, it is time for a careful review of the facts.

These hearings are also timely in that there are increasing rumors of a civil defense gap, with the Soviet Union well in the lead.

In this year's annual report, Defense Secretary Rumsfeld stated that, and I quote:

> An asymmetry has developed over the years that bears directly on our strategic relationship with the Soviets and on the credibility of our deterrent posture. For a number of years, the Soviets have devoted considerable resources to their civil defense effort which emphasizes the extensive evacuation of urban populations prior to the outbreak of hostilities, the construction of shelters in outlying areas, and compulsory training in civil defense for well over half the Soviet population. The importance the Soviets attach to this program at present is indicated not only by the resources they have been willing to incur in its support, but also by the appointment of a deputy minister of defense to head this effort.

Now, the term "asymmetry" used by the Secretary sounds to a non-expert like me like a four-bit word for "gap." We have heard a great deal over the years about gaps that never materialized or proved unimportant. Yet we have spent a lot of money to eliminate the non-existent or the insignificant. It is for this reason that the committee last week published the declassified text of the 1957 Gaither Report which invented the first missile gap.

STATEMENT OF HON. PAUL NITZE, FORMER SECRETARY OF THE NAVY, DEPUTY SECRETARY OF DEFENSE, AND MEMBER OF THE SALT DELEGATION

Mr. NITZE. Mr. Chairman, my interest in the questions which this committee is discussing began in 1944 when I was asked to be a director of the U.S. Strategic Bombing Survey. The required qualification of the directors was that they have no prior knowledge of military strategy or of air power, and could thus be presumed to be unbiased in appraising the effects of the immense U.S. strategic air effort in World War II. I spent the next 2 years in Europe and then in the Pacific in intensive work, in association with what I believe to have been the best talent available to this country, to try to understand something about both subjects. In the Pacific portion of the survey, as Vice Chairman, I was in effective command of the operation, including the detailed study of the effects of the weapons used at Hiroshima and Nagasaki.

Since that time much has changed. Weapons have increased in yield and missiles now have an intercontinental range. But these changes are hardly as revolutionary as the changes brought about by the role of effective air power in World War II and of the introduction of nuclear weapons in its closing phase. After all, the largest number of our nuclear reentry vehicles today are Poseidon warheads, each of which has an equivalent megatonnage less than twice that of the weapons used at Hiroshima and Nagasaki.

At Hiroshima and Nagasaki there was no air-raid warning and very few people availed themselves of the crude civil defense facilities which were available. Most of those that did, even at ground zero, in other words, directly under the explosion, which was at the optimum height of burst, survived. The trains were operating through Hiroshima 2 days after the explosion.

Let me paraphrase from an interchange I had in 1960 with Colonel Lincoln, head of the faculty at West Point, on this subject:

The Russians are careful students of Clausewitz. I do not believe they would ever ignore either the danger that a war once started might escalate to the full violence which the pure theory of war might indicate; on the other hand, they would never forget that war is a tool of policy and that every effort must be made to avoid letting it so escalate.[1]

[1] In this connection the following quotation from *Communist of the Armed Forces* in November 1975 is pertinent: "The premise of Marxism-Leninism on war as a continuation of policy by military means remains true in an atmosphere of fundamental changes in military matters. The attempt of certain bourgeois ideologists to prove that nuclear missile weapons leave war outside the framework of policy and that nuclear war moves beyond the control of policy, ceases to be an instrument of policy and does not constitute its continuation is theoretically incorrect and politically reactionary."

On the other hand, I can well imagine that they might consider a controlled nuclear conflict in which significant military targets, but not urban-industrial targets, are the initial objects of attack, if they thought war unavoidable.

In conclusion, I would like to comment on this committee's print containing the Gaither Report of 1957.

I have now read that report for the first time in nearly 20 years. I am impressed—especially in light of the information then available to the Gaither committee—by the care and comprehensiveness of that committee's examination of the problems assigned to it for study. I note in contrast the cavalier imprecision reflected in the foreword prepared by this committee's staff.

It is not true that the Gaither Report ignored arms control, nor is it true that the report spoke of U.S. strategic inferiority as then a fact. To the contrary, the Gaither Report described the United States as then "capable of making a decisive attack on the U.S.S.R." In view of SAC's vulnerability "to a surprise attack in a period of lessened world tension," the Gaither Report also noted the U.S.S.R.'s capability to make "a very destructive attack on this country."

The report then observed, "As soon as SAC acquires an effective 'alert' status, the United States will be able to carry out a decisive attack even if surprised," and it anticipated that juncture "as the best time to negotiate from strength, since the U.S. military position vis-a-vis Russia might never be so strong again."

In attempting to disparage the Gaither committee's analysis, the staff foreword cites a subsequent estimate "* * * that at the time of the Gaither Report the Soviet Union probably had fewer than a dozen operational ICBMs." In fact, at the time of the Gaither Report—only a few weeks after the sputnik launching—the Soviet Union obviously had no operational ICBMs. The Gaither Report made no assumption to the contrary. Indeed, it postulated 1959 as the probable year the Soviet Union would first have operational ICBMs; in fact, they first became operational in 1960. What was crucial at the time was not only the question of how many ICBMs would be operational when, but even more importantly the question of the speed with which the U.S. Air Force could achieve adequate early warning facilities and an appropriate alert posture.

The Gaither Report focused attention on those questions.

STATEMENT OF HERMAN KAHN, DIRECTOR, HUDSON INSTITUTE

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It is not true that the Democrats raised the issue of a missile gap against the Republican administration. That was a Republican statement. The Republicans predicted the Russians would have 300 missiles by 1960. But at the same time, the Republican administration said this wouldn't make any difference, because we had 2,000 bombers and they were more important than 300 missiles.

The great contribution of the Gaither Report, as Paul just said, was to make clear that if the Soviets had 300 missiles and we did not have any kind of warning system, then we might not have 2,000 bombers, because they could be destroyed by a surprise attack while still on the ground.

I also made clear, that while the Soviets probably would not have 300 operational missiles in 1960, if they did have them, we would be in trouble—that is, despite the predictions by the Republican administration we did not think they had such a force—but we were not sure.

What does one do when the other side may be able to do something in the near future and if one waits until he is certain before reacting, it is too late, while if one reacts early it may turn out to have been unnecessary?

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Let me also make a remark about a release I saw from this committee which listed a series of predicted gaps which did not occur. In at least half the cases, people were rather clear that the gap might not occur, but they were not sure.

[Additional remarks:]

But they felt they had to worry about it ahead of time and even make some preparations because they could not afford to wait until all the facts were in.

Let me ask a question: What do you do if the other side exhibits a weapon system and has the production capability? You are not quite sure what he is going to do. Do you wait until he does it or do you worry about it?

In general this is a very complicated issue. In some cases, we almost have to make preparations ahead of time, even though they may be wasted. In other cases, we should wait until we are more sure; in still other cases, one just hopes for luck. But one should not, in my judgment, downgrade responsible officials who get concerned under such circumstances.

I might also draw attention to some studies done by Albert Wohlstetter. It is pointed out in these studies that in most cases, we have underestimated rather than overestimated U.S.S.R. future capability. I will ask that this report be sent to the committee.

If you look at the record, there has been more a problem of underestimation than overestimation. This is true in terms of the number of missiles the Soviets have had over time and in terms of Soviet capability on all kinds of other issues. We tend to remember the discussion when some hysterical people overstate the problem; then it turns out to be wrong. I would argue this is not at all the characteristic problem.

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Probably an even better prototype for the situation we are thinking about is pre-World War II. After World War I, much of the world became sick of war, and war became "unthinkable" to most people, particularly in the victorious "Allied Powers." Strategists and publicists talked about poison gas and knock-out blows; they thought all the capital cities would be destroyed by poison gas in the first few days of a war. They did not understand the idea of limitations in warfare—of mutual deterrence even after hostilities have broken out.

When Hitler got elected in 1933, people became interested in larger defense budgets. Then he marched into the Rhineland and, of course, defense budgets increased slightly. Then there was the Anschlus and then Munich, and more substantial increases in military budgets. With the invasion of Czechoslovakia, everybody got deeply concerned. Then, finally, there was the invasion of Poland, the formal declaration of war and then 7 months of more or less "phony war." As a result there was opportunity on both sides for 7 months' of full-time war production, before the war really opened up.

We would argue that similar possibilities should be considered today. Nobody is interested in jumping into a nuclear war today. Nobody is going to want to execute the usual picture of nuclear war, in which each side presses every button and goes home. It is extraordinarily difficult to believe such a scenario.

It might happen. But I would be willing to bet, if this were a betting matter, 50 to 1 against it.

On the other hand, the situation might arise in which there was a declaration of war, followed by a phony war, or a serious confrontation in which there were credible threats of war. By the way, in such a confrontation, the following dialog tends to occur.

Both sides are saying to the other side, "There is absolutely nothing at risk which justifies this terrible danger to which we are subjecting each other and the rest of the world. It is clear that whatever we are arguing about is simply not worth the risk of a thermonuclear war. Therefore, one of us has to be reasonable—and it isn't going to be me."

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Finally, a last point. When we write scenarios for nuclear war, we find it difficult to write a credible scenario which doesn't involve months or weeks of warning. I would guess we are as good at writing scenarios as anybody in the world. We have certainly written as many.

I want to warn the committee, on the other hand, that when we looked at World War I, we didn't find that scenario plausible. The mere fact we can't write a plausible scenario for a war doesn't mean it can't occur, because one can find historical examples to the contrary.

Nevertheless, every scenario we write for nuclear war involves days, weeks or months of tension. Evacuation, last moment mobilizations are extraordinarily possible. By the way, evacuations occur not as a result of secret intelligence or in any attempt to try to outrun the missiles or the bombers. The *New York Times* and the *Washington Post* provide the warning perhaps days before the attack. People or governments then get frightened and decide to decrease their vulnerability to attack. The idea is, can you exploit such warning if it is printed in the papers?

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TYPICAL STRATEGIC MOBILIZATION SCENARIOS

Of the four scenarios given below, the first two are history, the third used to be the great fear of NATO, and the fourth is probably the great fear of the Warsaw Pact.

1. The "phony war," 1940 (5 months):

(a) Pre-crisis arms competition (UK, France, Germany and the U.S.S.R.).

(b) A major series of political-military crisis—
Militarization of the Rhineland (1936);
Anschluss (Austria) (1938);
Sudeten crisis (1938–39);
War in Poland (1939).

(c) De-escalation and negotiation (antagonists began a rapid buildup fearing a resumption of full scale conflict).

2. Korea (1950–53):

(a) Pre-war politico-military crises—
Soviet invasion of Iran (1946);
Soviet takeover of East European nations (1945–48);
Berlin blockade (1948);
Soviet intervention in Turkey and Greece;
Soviet military buildup, post WW-II.

(b) Major turnabout in U.S. policy—
Factor of four increase in defense expenditures in 18 months;
Massive emphasis on strategic preparedness, especially active defense.

3. Successful Soviet attack on W. Berlin and subsequent de-escalation.

4. Uprising in East Germany gets out of control and escalates.

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CHARACTERISTICS OF A SPECIAL MOBILIZATION SCENARIO: A FORMAL DECLARATION OF WAR BY THE U.S.

1. The declaration would have solemn and especially great significance for our enemies, allies, and neutrals.

2. The information transferred would have:

(a) Unambiguous factual content of great importance;

(b) Undeniable implications and symbolism;

(c) Highly uncertain interpretations or implications.

3. Its existence would preempt "ordinary" crisis negotiation and deny the stability of any recent *fait accompli*.

4. In some extreme crises it could be temporizing—a declaration is not a spasm response—and lead to deescalation of actual fighting.

5. But it implies a rapid response to any increased use of force.

6. It tends to force a decision by allies to cooperate actively.

7. It would justify many peripheral actions (blockades, interdiction, property confiscation, internment of hostile aliens, etc.).

8. It would tend to unify the national response—and increase defense spending enormously through mobilization.

9. It would convey the unambiguous message that a *formal* peace treaty will be required to settle all the important issues.

ROLE OF RESEARCH FOR MOBILIZING ACTIVE DEFENSES

1. Missile defense probably would be the most important and expensive effort.

2. Lead-time reduction becomes extremely important.

3. A program is required to facilitate rapid massive procurement of mutually reinforcing systems—
Boost phase interception;
Mid course interception;
Terminal interception.

4. A capability may soon be needed to support a war in space.

5. A capability is required for integration into other—high priority strategic mobilization programs—
Air defense;
Civil defense.

Major research objective: design systems which are highly effective, mutually supporting and which can be rapidly deployed at high levels of expenditure.

Appendix I

Paul Henry Nitze

In the spring of 1969, Paul Henry Nitze was appointed the representative of the Secretary of Defense to the United States Delegation to the Strategic Arms Limitation Talks with the Soviet Union; a position he held until June 1974, at which time he resigned.

Mr. Nitze resigned from his duties as Deputy Secretary of Defense on January 20, 1969, a position he had held since July 1, 1967, succeeding Cyrus R. Vance.

Mr. Nitze was serving as 57th Secretary of the Navy when he was nominated by former President Lyndon B. Johnson on June 10, 1967, to become Deputy Secretary of Defense. He was confirmed by the United States Senate on June 29, 1967.

The late President John F. Kennedy nominated Mr. Nitze to be Secretary of the Navy on October 14, 1963. At that time he was serving as Assistant Secretary of Defense (International Security Affairs), having assumed that position on January 29, 1961. He began his duties as Secretary of the Navy on November 29, 1963.

Graduated "cum laude" in 1928 from Harvard University, Mr. Nitze subsequently joined the New York investment banking firm of Dillon Read and Company. In 1941, he left his position as Vice President of that firm to become financial director of the Office of the Coordinator of Inter-American Affairs.

From 1942–1943, he was Chief of the Metals and Minerals Branch of the Board of Economic Warfare, until named as Director of Foreign Procurement and Development for the Foreign Economic Administration.

During the period 1944–1946, Mr. Nitze was Vice Chairman of the United States Strategic Bombing Survey. He was awarded the Medal of Merit by President Truman for service to the nation in this capacity.

For the next seven years, he served with the Department of State, beginning in the position of Deputy Director of the Office of International Trade Policy. In 1948, he was named Deputy to the Assistant Secretary of State for Economic Affairs. In August, 1949, he became Deputy Director of the State Department's Policy Planning Staff, and Director the following year.

Mr. Nitze left the federal government in 1953 to become President of the Foreign Service Educational Foundation in Washington, D.C., a position he held until January 1961.

Mr. Nitze is Chairman of the Advisory Council of The Johns Hopkins School of Advanced International Studies in Washington, D.C., and also serves on the Board of Trustees of the University. He holds memberships on the Board of Directors of Schroders, Inc., in New York, and Schroders, Ltd., in London, The American Security and Trust Company of Washington, D.C., Northwestern Mutual Life Mortgage and Realty Investors of Milwaukee, Wisconsin, and is Chairman of the Board of the Aspen Skiing Corporation.

Herman Kahn

Herman Kahn was born in Bayonne, New Jersey, in 1922. He received a B.A. from UCLA in 1945 and an M.S. in physics from the California Institute of Technology in 1948. He was associated with the Rand Corporation before becoming in 1961 the principal founder and director of the Hudson Institute, a research organization studying public policy issues, with headquarters in Croton-on-Hudson, N.Y. His international reputation as a strategic warfare analyst or, as the *New Republic* put it, one of "the prophets of strategic reality," is based on his work at the Institute and on his books: *On Thermonuclear War* (1960), *Thinking about the Unthinkable* (1962), *On Escalation* (1965 and, revised Pelican

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STATEMENT OF E. P. WIGNER [1] FOR THE JOINT COMMITTEE ON DEFENSE PRODUCTION

[1] Dr. Wigner is a Nobel Laureate and an emeritus professor of physics at Princeton University and has long been associated with civil defense issues. He edited a 1968 study *Who Speaks for Civil Defense?*

THE EFFECTIVENESS OF CIVIL DEFENSE

This writer became convinced of the possible effectiveness of civil defense measures when he served as a member of the General Advisory Committee to the U.S. Atomic Energy Commission.

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Are the U.S.S.R. and China the only countries with elaborate and well developed civil defense systems? No—most of the peace-loving countries also have such systems, based on blast shelters, and their yearly expenditures per person on such defense is about 15 times greater than ours. This has been, so far, about 40¢ per person a year. Incidentally, the Swiss civil defense repeats our President Kennedy's message: (Civil defense) "is insurance we trust, will never be needed"—its greatest accomplishment is, according to the Swiss, that it will *not* have to be used, that it will divert the aggressive instincts of possible opponents.

It is easy to conclude that an effective civil defense is not only desirable, it is also possible.

IS CIVIL DEFENSE NECESSARY?

What is the principal danger that threatens us in the present absence of an effective civil defense? It is the possibility of the U.S.S.R. evacuating its cities, dispersing their population, and then making demands on us, under the threat of a nuclear attack, approximating those made by Hitler or Czechoslovakia which led to the Munich pact. This left Czechoslovakia essentially defenseless.

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THE ARGUMENTS AGAINST CIVIL DEFENSE

The argument which we heard after the U.S.S.R. civil defense efforts became generally apparent was that our installation of protection for our people would only induce the U.S.S.R. to augment its aggressive capability. We now know that such augmentation took place even though we did not organize a vigorous civil defense effort. One of the two arguments we now hear, the civil defense is too expensive, seems almost ridiculous. If Switzerland, Sweden, etc., *even China*, can afford the more costly, the blast shelter method, we with the highest per capita national wealth, can also surely afford the defense of our people. The other argument, in the words of one of the most learned opponents of civil defense, S. Drell, is that it would lead to an "escalation of the apprehension from the mood of today, vis-a-vis the dangers of a nuclear exchange between the U.S. and the Soviet Union." Should the apprehension of the danger not be greater now, where we have no effective defense, than it would be when we have such defense? Or is it proposed that we should lull the common people into ignorance of the true situation? It is remarkable also that the U.S.S.R. is not criticised for fostering the "apprehension" of its own people. One must conclude that the varying arguments against civil defense have little validity.

A FEW PROPOSALS RELATED TO OUR DEFENSE

The first change I would advocate is to stop maintaining that a nuclear war would be the end of mankind. Such a statement may give the impression to an opponent that he can achieve anything by threatening with a nuclear war. After all, he would argue, the opponent (that is us) will make any sacrifice to avoid the "end of mankind". Hence, if he is threatened with extinction he will give in, particularly if the threat comes from a party which does not believe that the war precipitated by him will lead to the "end of mankind". Instead of such a blatantly incorrect statement, it would be better to subscribe to Chuykov's doctrine that "knowledge and the skillful use of modern protective measures" will make it possible to provide effective protection. At least, we could adhere to Kissinger's earlier (1957) statement: "While it (civil defense) cannot avert the traumatic effect of vast physical destruction, its efficient operation may make the difference between the survival of a society and its collapse."

The second measure which I consider to be urgent is to establish better contact with the people at large. This makes it desirable for DCPA to expand its staff by the employment of people who can establish a contact with the population at large, who can speak and write the truth convincingly. One of the functions of these advisors would be to help the high schools to give instruction on the nature of nuclear explosions and the defense against the effects of these. This is a subject which is foreign to most present high school teachers, and the advisor could and should help them to acquire the necessary knowledge. After all, the Federal Government now intends to support the local schools and can well suggest that these contribute to the protection of the country. The high school instruction on civil defense—obligatory in the U.S.S.R.—would be very useful since, after all, we learn best when we are young and we learn most non-elementary facts from our teachers. But even more generally, the establishment of a close contact between those who protect our freedom, and those whose freedom is protected, would be very desirable; and acquainting people at large with the methods and effectiveness of civil defense would provide an avenue toward this goal. It may not be easy to find people who know about the methods and effectiveness of civil defense and who are also able and interested in communicating this and much other knowledge to the people at large, but every effort should be made to find such people and support them.

The last suggestion I wish to make is that the DCPA budget should certainly not be cut. It should steadily be increased until, in a few years, it reaches the per capita level of other peace-loving and non-expansionist countries, such as Switzerland, Holland, Sweden, etc. For reasons given in the rest of my statement, this would be of decisive importance for maintaining a valid, widely endorsed, and vigorous defense effort for our country—and it would support all freedom-directed nations. Their independence does depend to a certain degree on our strength and our ability to stand up for them. The examples of Hungary, Czechoslovakia, Poland—to mention only a few—show that such independence does not come freely.

Let me end on a bit more hopeful tone which is, however, as sincere as was the rest of my statement. This is the hope that an effective civil defense may not only protect our country and our freedoms, but it may

(Gross exaggerations, assuming Nevada desert type terrain with no thermal shadows by city skylines, no duck and cover, no clothing and fraudulent blast effects data which ignores Hiroshima's evidence)

APPENDIX III

U.S. CIVILIAN NUCLEAR FATALITY ESTIMATES [1] FOR VARIOUS COUNTERFORCE ATTACK SCENARIOS

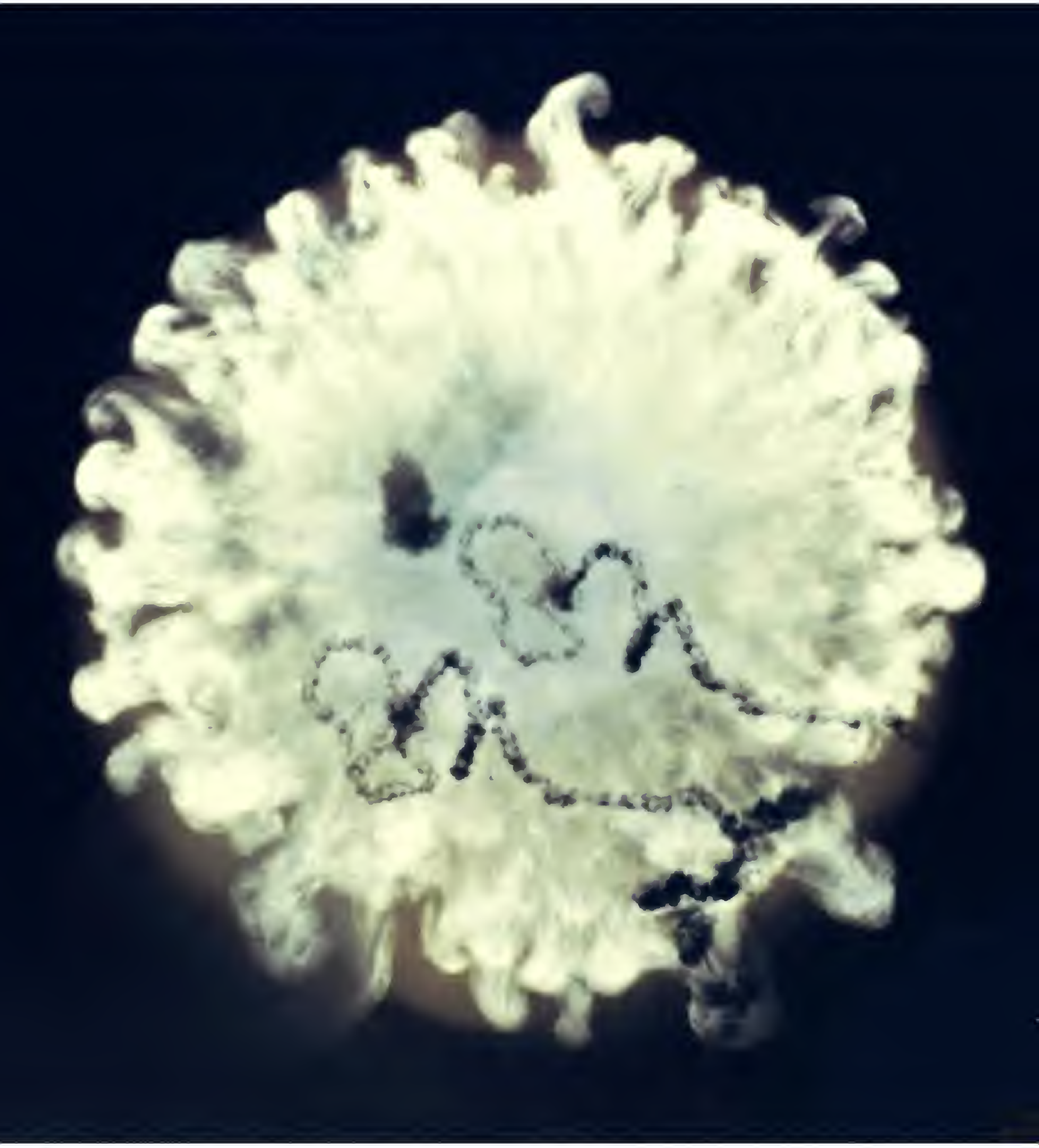
Type of attack	Assumptions	Estimated fatalities
Comprehensive attack:		
Case 1, 60 percent destruction of military targets.	1 optimum height of burst and 1 surface burst warhead per each of 1,054 ICBM silos; pattern attack of SAC bases: unspecified attack on 2 SSBN support bases; good shelter posture.	3, 200, 000
Case 2, 60 percent destruction of military targets.	2 optimum height of burst warheads per each of 1,054 ICBM silos; no pattern attack of SAC bases; unspecified attack on 2 SSBN support bases; poor shelter posture.	6, 700, 000
Case 3, 57–60 percent destruction of military targets.	2 surface burst warheads per each of 1,054 ICBM silos; pattern attack of SAC bases; unspecified attack on 2 SSBN support bases; very poor shelter posture.	16, 300, 000
ICBM only attack:		
Case 1	2 550 kt optimum height of burst warheads per each of 1,054 ICBM silos.	[2] 4, 000, 000
Case 2, 42 percent silo destruction.	1 550 kt surface burst and 1 550 kt optimum height of burst warhead per each of 1,054 ICBM silos.	5, 600, 000
Case 3, 80 percent silo destruction.	1 3 Mt surface burst and 1 3 Mt optimum height of burst warhead per each of 1,054 ICBM silos.	18, 300, 000
Case 4	2 3 Mt surface burst warheads per each of 1,054 ICBM silos	[3] 20, 000, 000
Airlift attack: [4]		
Case 1	1 200 kt cruise missile warhead per each of 5 U.S. heavy airlift bases (Dover AFB, Del.; McGuire AFB, N.J.; Travis AFB, Calif.; Charleston AFB, S.C.; and McChord AFB, Wash.)	70, 000
Case 2	1 1.2 Mt SLBM per each of 5 U.S. heavy airlift bases	210, 000
Case 3	1 1.2 Mt SLBM per each of 5 U.S. heavy airlift bases uses offset targeting.	135, 000

[1] Department of Defense estimates as reported to the Senate Foreign Relations Committee, July 11, 1975, and published in "Analyses of Effects of Limited Nuclear War," pp. 12–24. Note that figures are fatalities only and not casualties and that attacks are restricted to military facilities (counterforce) rather than populated areas (countervalue). Shelter posture is a function of degree of hardening and the willingness of the population to use shelters.

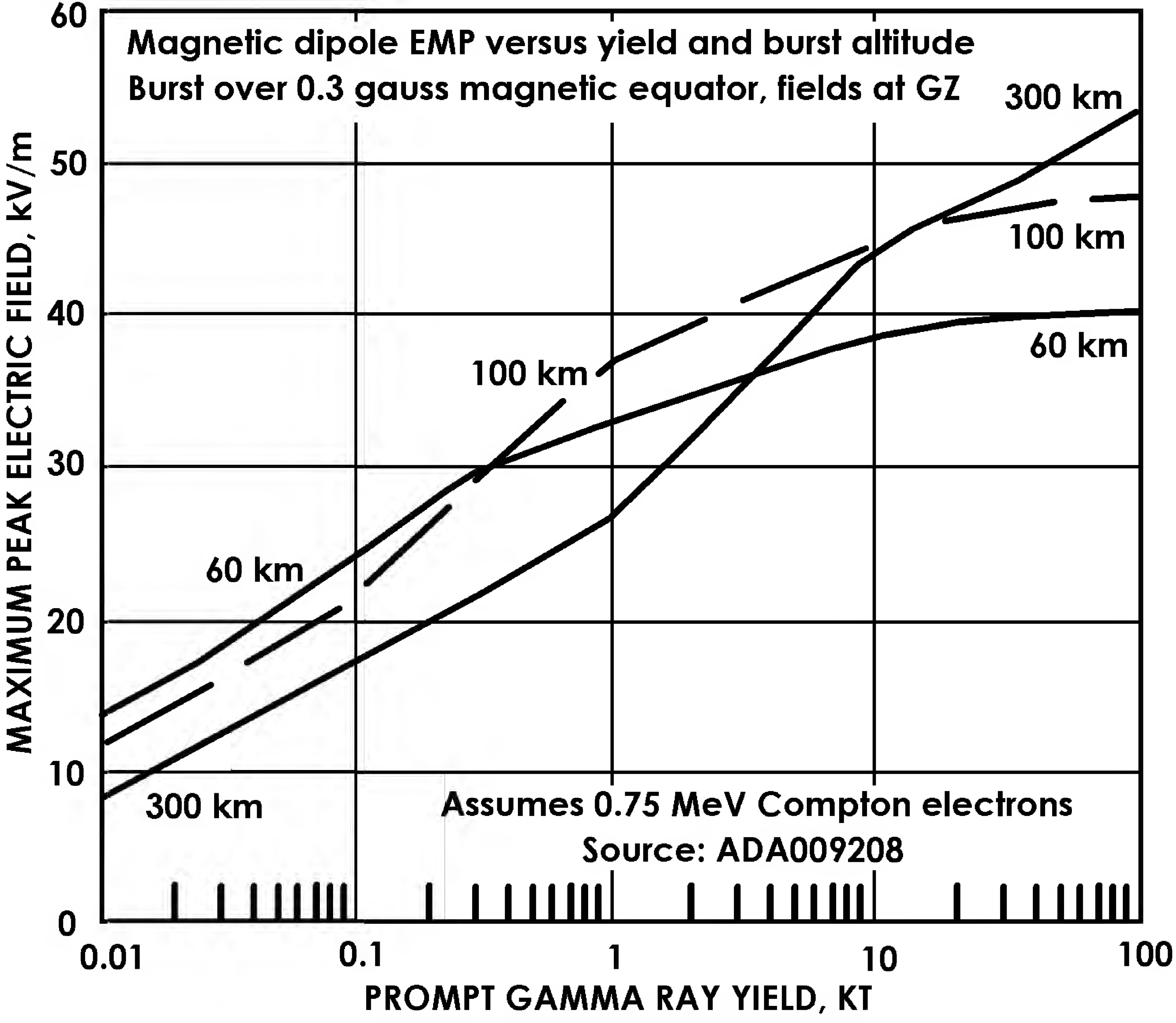
[2] Under.

[3] Circa.

[4] Assumes allied victories in a European war supported by U.S. military airlift provide incentives for destruction of major American airlift centers.



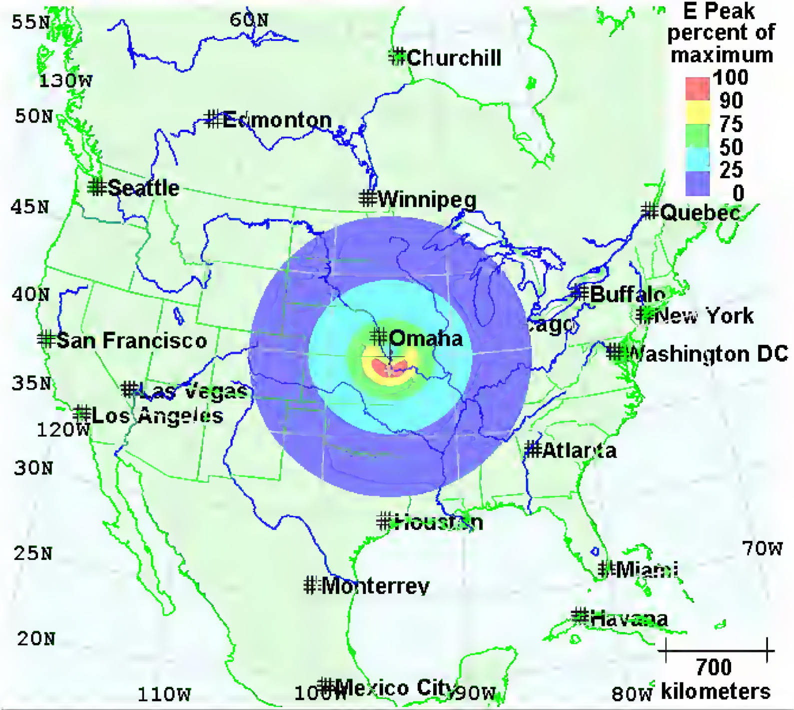
7 kt Checkmate burst, 147 km altitude


Magnetic dipole EMP versus yield and burst altitude
Burst over 0.3 gauss magnetic equator, fields at GZ
300 km
100 km
60 km
100 km
60 km
300 km
Assumes 0.75 MeV Compton electrons
Source: ADA009208
MAXIMUM PEAK ELECTRIC FIELD, kV/m
PROMPT GAMMA RAY YIELD, KT
0
10
20
30
40
50
60
0.01
0.1
1
10
100

PROMPT GAMMA RAY OUTPUTS FROM DIFFERENT NUCLEAR WEAPONS (SOURCE: J. A. NORTHROP, *HANDBOOK OF NUCLEAR WEAPONS EFFECTS*, DEFENSE SPECIAL WEAPONS AGENCY, 1996)

WEAPON TYPE	TOTAL PROMPT GAMMA RAY ENERGY OUTPUT IN MeV/kt	TOTAL PROMPT GAMMA RAY OUTPUT*	AVERAGE PROMPT GAMMA RAY ENERGY (MeV)
3 (Unboosted subkiloton implosion weapon, contemporary design; type I in the 1972 DNA-EM-1)	9.80×10^{22}	0.38 %	1.50
5 (Boosted fission implosion, modern design, 1 kt to a few tens of kt; new to EM-1)	1.04×10^{23}	0.40 %	1.61
8 (Thermonuclear secondary with a single yield, a few tens of kt to 5 Mt; type VII in the 1972 DNA-EM-1)	$3.55 \times 10^{23} W_{kt}^{-0.29}$	$1.37 W_{kt}^{-0.29}$ %	1.63
13 (Enhanced radiation, 1-10 kt; type V in the 1972 DNA-EM-1)	6.70×10^{23}	2.58 %	2.00

*Based on the conversion factor 1 kt = 2.6×10^{25} MeV, given in Table 1.45 of *The Effects of Nuclear Weapons*, 3rd ed., 1977 (the text of that book implies this is the rounded product of 180 MeV/fission and 1.45×10^{23} fissions/kiloton, giving 1 kt = 2.61×10^{25} MeV/kiloton). (The prompt gamma rays are the gamma rays released within about 20 nanoseconds of detonation by the actual fission process and by the inelastic neutron scatter by heavy nuclei in the weapon debris.)



Average value is 10.4% of the maximum (Fig 2-3 from Meta-R-320, 2010) for 75 km burst altitude shown.

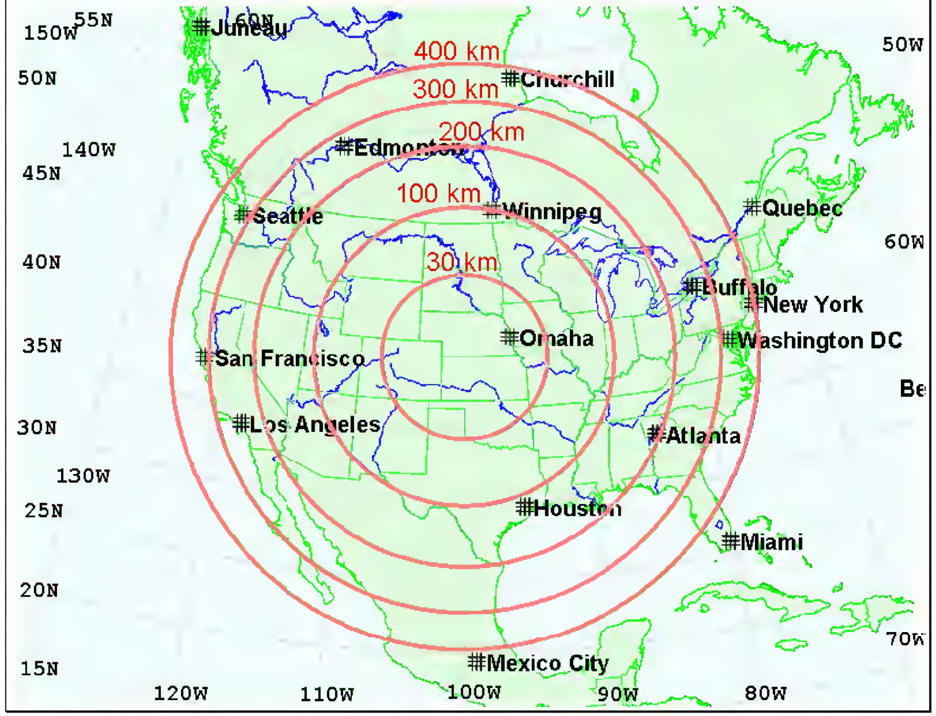


Figure 2-9. Samples of E1 HEMP exposed regions for several heights.

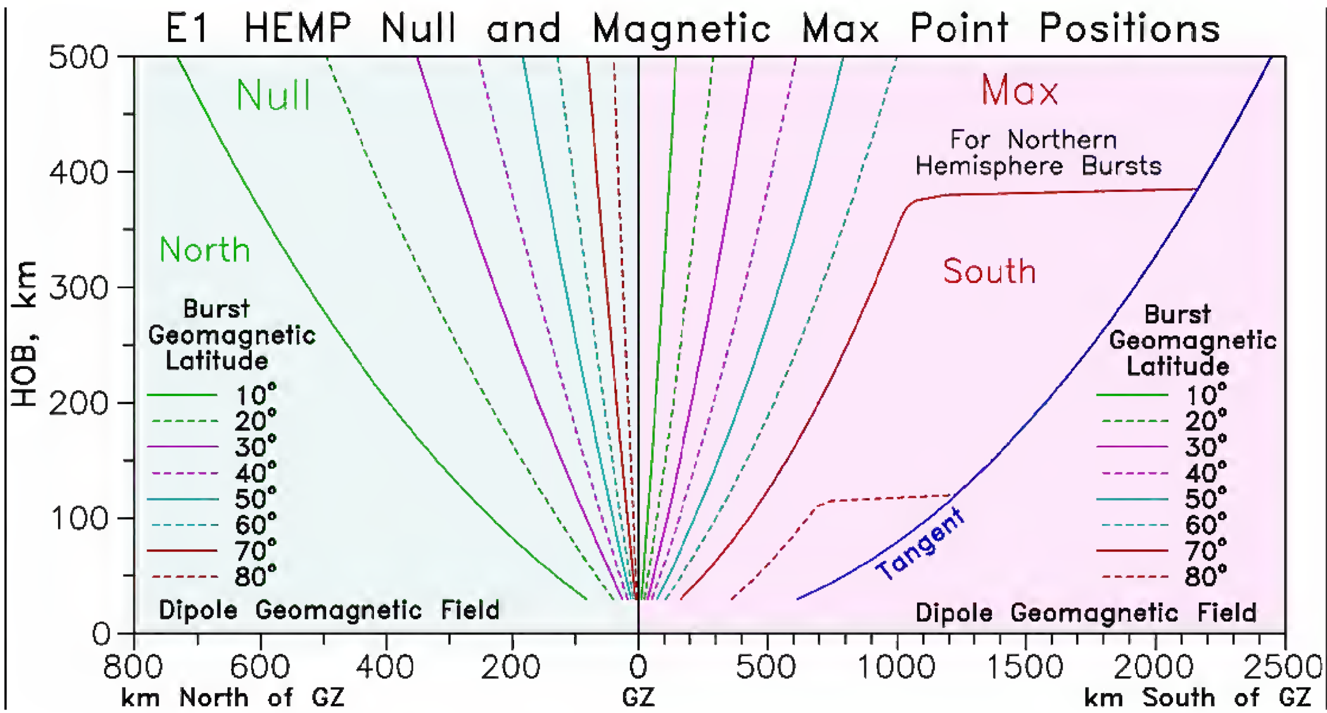


Figure 2-11. Positions of two special E1 HEMP points versus burst height.

A Nominal Set of High-Altitude EMP Environments

Conrad L. Longmire
Robert M. Hamilton
Jane M. Hahn

dip angle (from the horizontal) of 70°

B_0 = 0.56 Gauss

E_γ = 2 MeV

Y_γ = 10 kilotons

H = 400 km

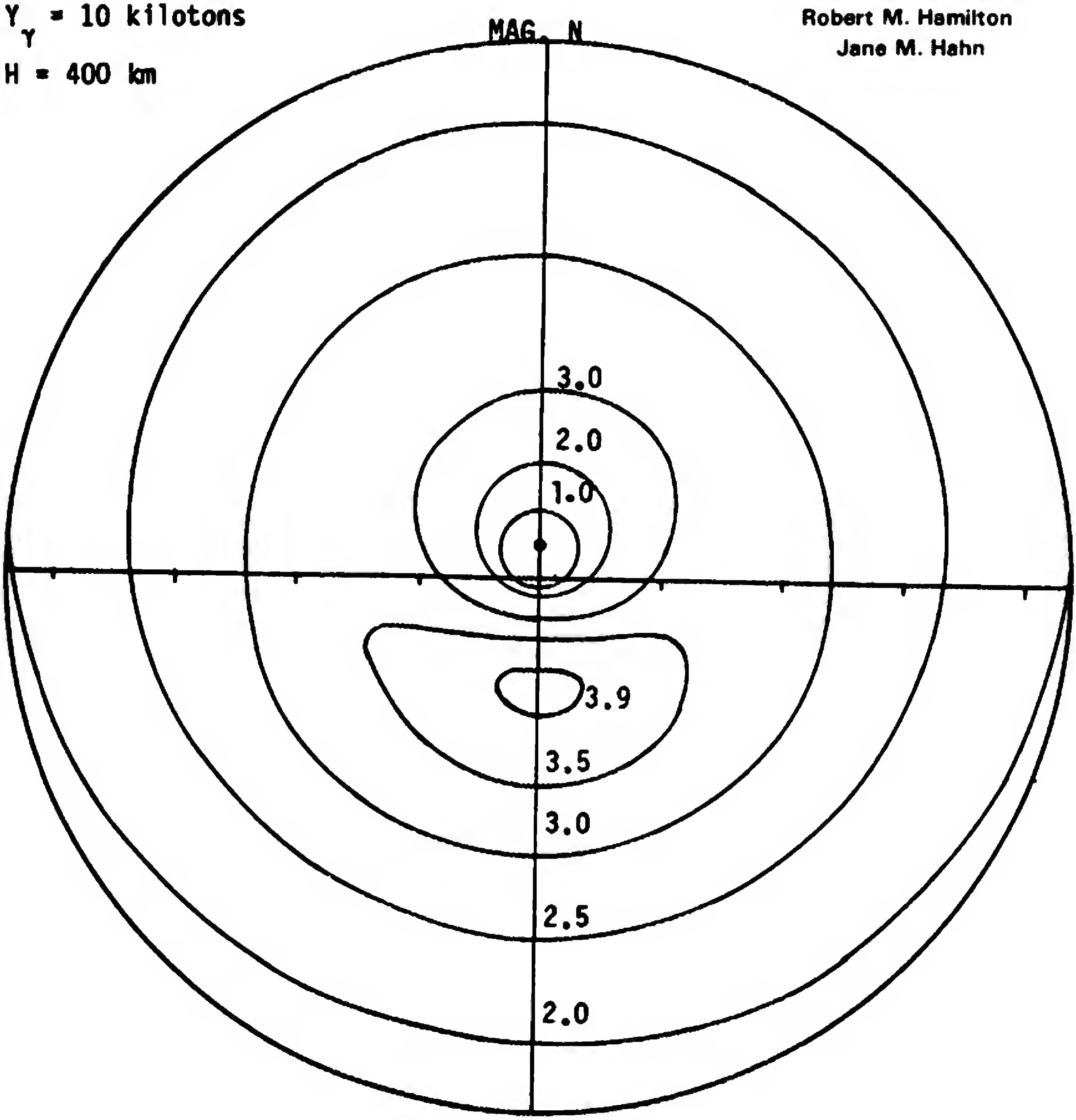
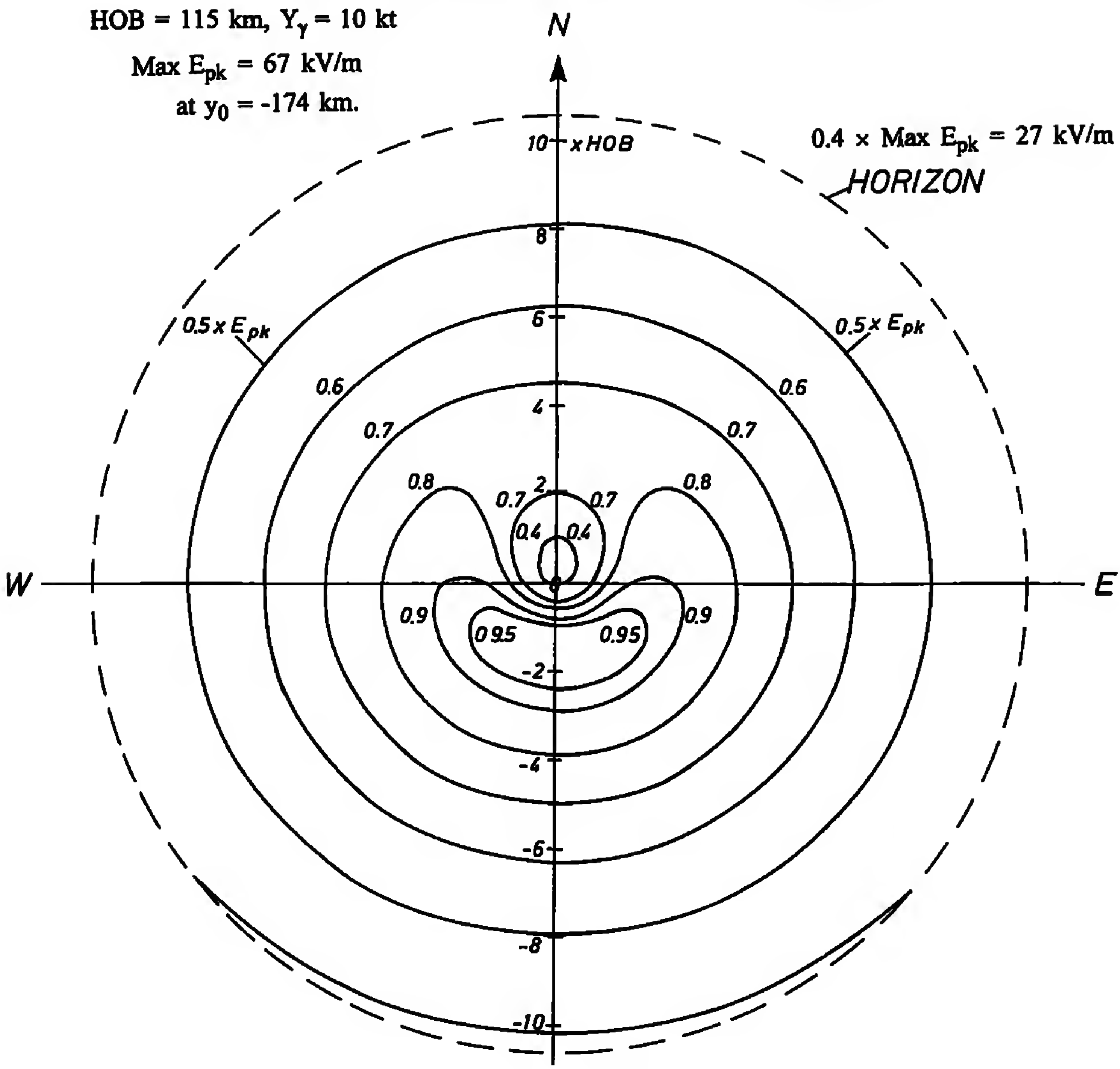
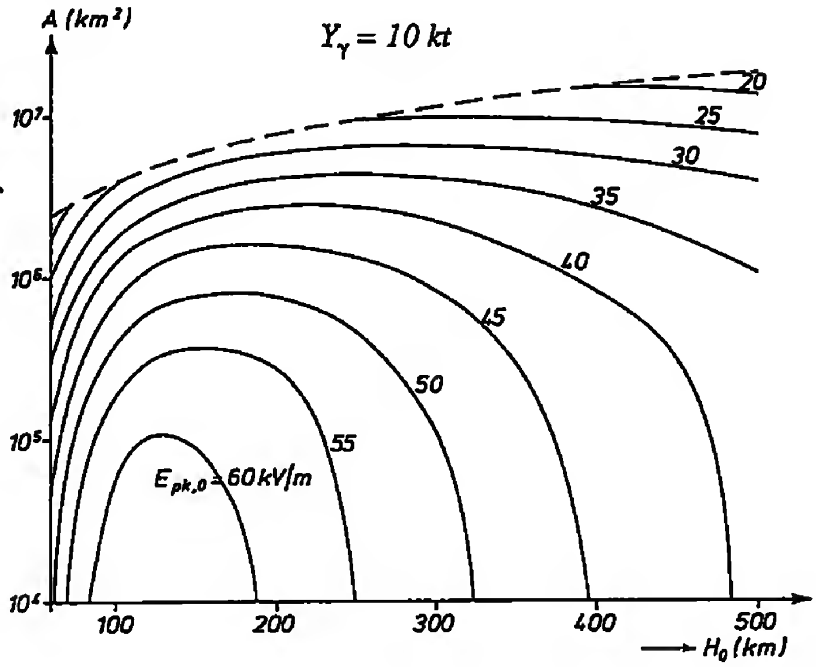


Figure 41. Contour plot of the peak value of the azimuthal electric field E_ϕ. Numbers on the contours are in units of 10^4 V/m. The outer circle is the horizon at 2200 km ground range.

EMP Theoretical Note 364 (1994), by K.-D. Leuthauser



Geomagnetic lattitude θ_0 = 50°
Magnitude of earth magnetic field B_0 = 4.7×10^{-5} T
Dip angle φ_0 = 67°



Area coverage versus burst altitude
(EMP Theoretical Note 365, 1995,
by K.-D. Leuthauser)

Did High-Altitude EMP Cause the Hawaiian Streetlight Incident?

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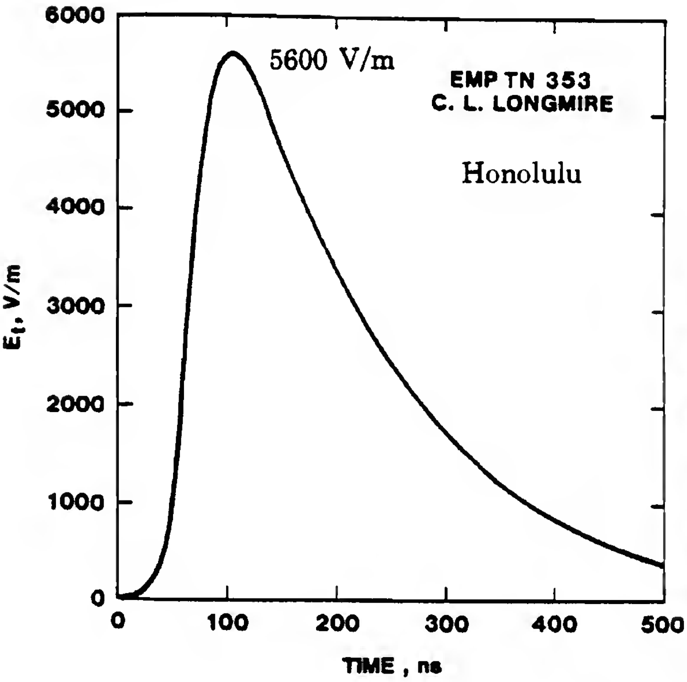
EMP created by the Starfish burst



View along Aleo, southeast, toward Ferdinand

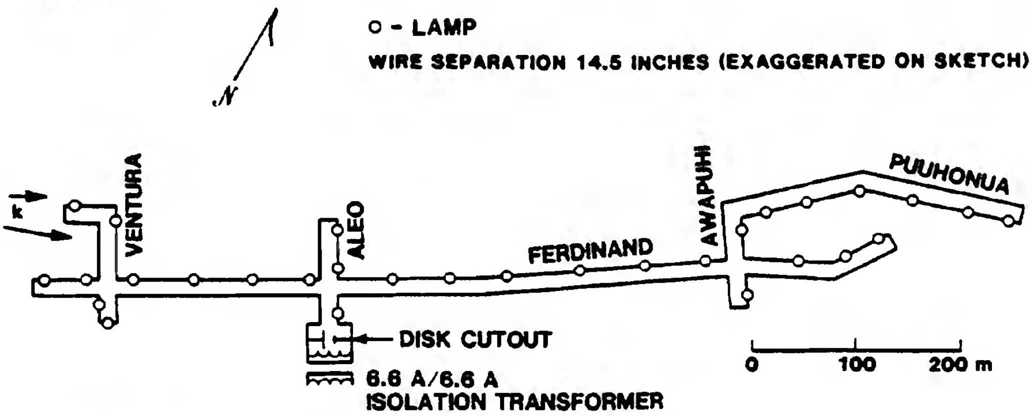


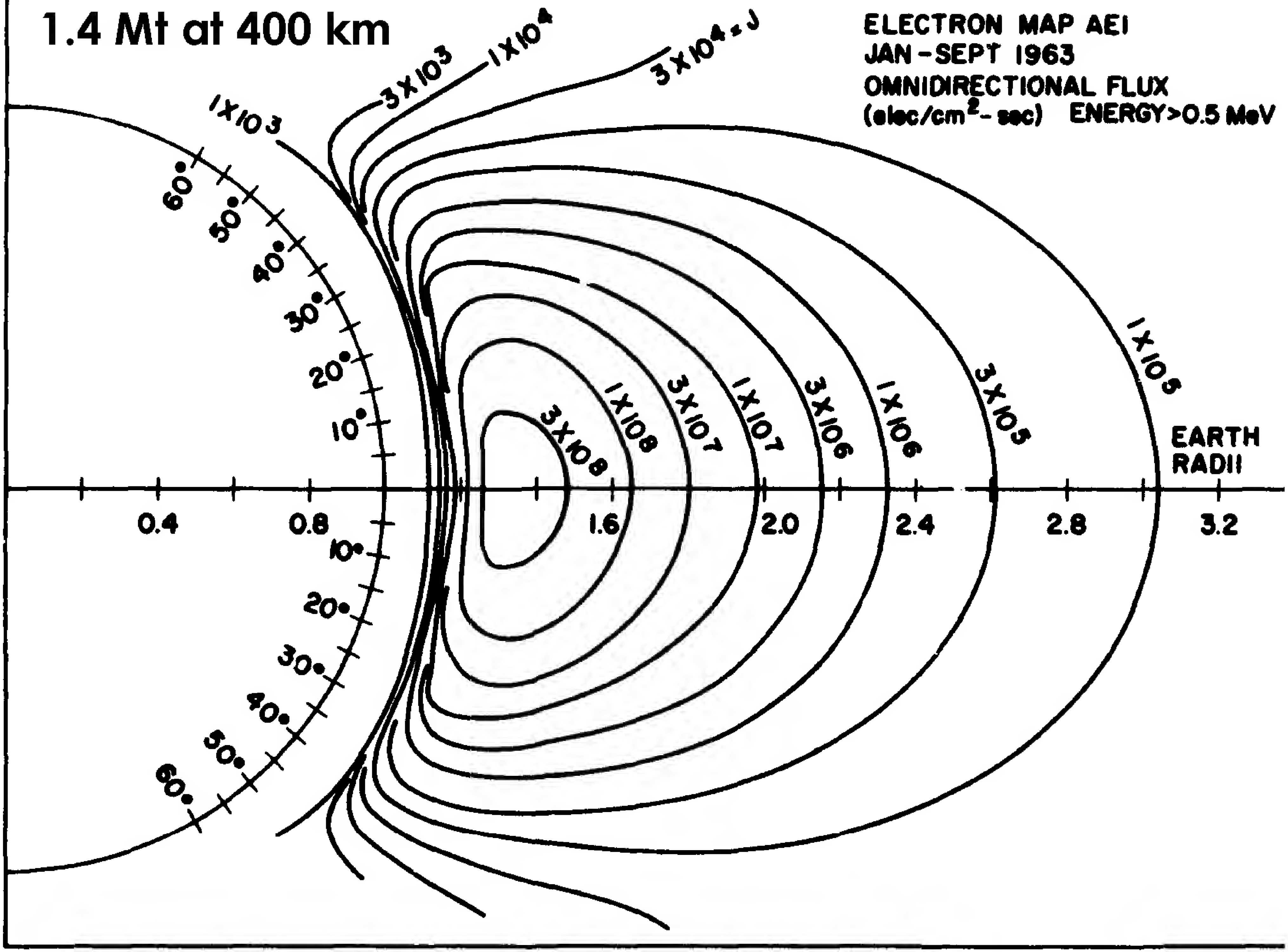
Figure 2. Ferdinand Street series lighting system in 1962

"The street lights on Ferdinand Street in Manoa and Kawainui Street in Kailua went out at the instant the bomb went off, according to several persons who called police last night," as reported on July 9, 1962, in the *Honolulu Advertiser*, a local paper. The article was reprinted in the Tuesday, February 21, 1984, edition that celebrated the 15th anniversary of Hawaiian statehood.

In the April 8, 1967, issue of the *Star-Bulletin*, Cornelius Downes described the fuses that failed, causing about 300 City streetlights to go out.

The Saturday, July 28, 1962, edition of the *Honolulu Star-Bulletin* included an article by Robert Scott (of their staff and also a professor at the University of Hawaii) that reviewed "What Happened on the Night of July 8?" He reported that a City-County streetlight department official in Honolulu attributed blown circuit fuses in nine areas to energy from the bomb.

Some 30 strings of streetlights failed, about 1% of the lights existing at the time. The failure of 30 strings was well beyond any expectations for severe storms (where ~4 failures were typical).



DNA 2524H Figure 4-16. Post-Starfish electron flux map.